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OPERATIONS
2 Welcome RSV *Nuyina*

SCIENCE
8 Cool cloud study

HISTORY
26 Van life

IN BRIEF
33 Rare sub-Antarctic orchid flowers far from home

CONTENTS

ABOUT THE COVER

Senior meteorology observer, Barry Becker, took this photo during an airdrop of supplies to Davis research station in September (see page 7). Barry pre-set the focus of his Nikon D750 on the distant station. When the aircraft arrived it took less than a minute between the packages exiting the aircraft and the chutes settling on the ice. Barry has previously wintered on Macquarie Island and spent two summers on the continent as the senior meteorologist.

The Australian Antarctic Division, a Division of the Department of the Environment and Energy, leads Australia's Antarctic program and seeks to advance Australia's Antarctic interests in pursuit of its vision of having 'Antarctica valued, protected and understood.' It does this by managing Australian government activity in Antarctica, providing transport and logistic support to Australia's Antarctic research program, maintaining four permanent Australian research stations, and conducting scientific research programs both on land and in the Southern Ocean.

Australia's Antarctic national interests are to:

- Preserve our sovereignty over the Australian Antarctic Territory, including our sovereign rights over the adjacent offshore areas.
- Take advantage of the special opportunities Antarctica offers for scientific research.
- Protect the Antarctic environment, having regard to its special qualities and effects on our region.
- Maintain Antarctica's freedom from strategic and/or political confrontation.
- Be informed about and able to influence developments in a region geographically proximate to Australia.
- Derive any reasonable economic benefits from living and non-living resources of the Antarctic (excluding deriving such benefits from mining and oil drilling).

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From the Director

The Australian Antarctic Division has been on an exciting journey these past six months as we work towards fulfilling a range of commitments under our Antarctic Strategy and 20 Year Action Plan. Among the highlights were the first steel cutting and subsequent keel laying for our new Antarctic icebreaker, and the announcement of the winners of our 'Name our Icebreaker' competition (page 2).

We put a lot of faith in Australian school students to name the vessel, which will be a critical component of Australia's Antarctic program for the next 30 years, and they did not disappoint.

> By the time you read this the competition winners – six secondary students from Tasmania and six primary students from Western Australia – will have made history, by being the first students to fly to Wilkins Aerodrome and spend time on the ice.

The winning name, RSV *Nuyina* (pronounced "noy-yee-nah") means "southern lights" in *palawa kani*, the language of Tasmanian Aborigines. It's a wonderful name for so many reasons. It continues the theme of naming ships after the shimmering curtains of light, including Sir Douglas Mawson's first ship *Aurora* and our current icebreaker *Aurora Australis*. It also celebrates the views of the children – more than 20 per cent of competition entries suggested an Aboriginal name – and it reminds us of the links between Tasmania and Antarctica and when, some 200 000 years ago, Tasmanian Aborigines would have seen the southern lights.

We have also made great strides towards the development of an overland traverse capability and associated mobile station, to support deep-field scientific research, including the million year ice core drilling project (page 6). Last season, two of our team spent a good part of their summer on traverse with British and French teams, studying the different traverse technologies and methodologies employed by each program. The Australian team is now working to recommend a way forward. Up until the early 2000s, Australia had some 40 years' experience undertaking heavy traverses, and it will be exciting to reinvigorate this expertise.

In September we completed the final phase of a 'proof of concept' to deliver supplies to Antarctica outside the summer shipping season, using the Royal Australian Air Force's C-17A aircraft (page 7). A mid-air refuelling enabled the aircraft to make the 10 000 km round trip between Hobart and Davis research station and drop nine tonnes of cargo to isolated expeditioners. The capability will allow us to pre-position equipment and supplies for station and science projects, saving valuable time when the summer season gets underway.

Photo: Adam Roberts

This 2017–18 season is shaping up to be a busy time for our scientists. The *Aurora Australis* recently had a 'facelift, to strengthen one of her decks to accommodate an additional seven tonnes of atmospheric instruments. As the ship plies the Southern Ocean between October and April, the instruments will gather information on clouds and aerosols (page 8). Collaborators from the United States will also fly transects over the Southern Ocean and the ship, for six weeks, in an instrumented aircraft. Together, the data will help us understand the occurrence of supercooled water clouds – which remain as liquid water at temperatures well below freezing – and improve how clouds are represented in climate models.

Two teams of glaciologists will also return to the Totten and Sørsdal glaciers this season to continue important work on the fundamental processes driving ice shelf thinning. Last season both teams deployed equipment to monitor glacial processes and this season should see a good collection of data retrieved (page 12).

Finally, you'll find a range of interesting historical stories about Antarctic life and culture in this issue. Films, field vans and motorbikes helped expeditioners enjoy well-earned breaks in a life far from loved ones, and to explore the Antarctic environment. These diversions still exist, albeit in a more modern form. While many aspects of our program modernise, some things stay the same.

Dr NICK GALES
Director, Australian Antarctic Division

Welcome RSV *Nuyina*

Australia's new Antarctic icebreaker has been named RSV *Nuyina* (pronounced "noy-yee-nah"), meaning "southern lights" in *palawa kani*, the language of Tasmanian Aborigines, after a national competition amongst school children in years 5 to 8.

More than 800 entries were received from primary and secondary schools across all states and territories, with the winning entries provided by St Virgil's College in Hobart, Tasmania, and Secret Harbour Primary School, near Perth in Western Australia.

As this magazine went to press the 12 students were preparing for their flight to Wilkins Aerodrome, to experience the icy continent first hand, including exploring an Antarctic field camp, drilling an ice core and taking scientific observations.

Four runner-up prizes of a $500 technology voucher were awarded to Rokeby Primary School in Tasmania, Ulladulla High School in New South Wales, Essex Heights Primary School in Victoria and Cowell Area School in South Australia.

More than 20 per cent of competition entries suggested Aboriginal names. The Tasmanian Aboriginal Centre (TAC), which approved the use of nuyina, said it was a fitting choice, as Aborigines of lutruwita (Tasmania) have always been seafarers and builders of seafaring vessels.

Ms Daisy Allan, a Language Worker from the TAC, said the word nuyina was first shared by Aborigines with government agent George Augustus Robinson in August 1831, near Ansons Bay on Tasmania's north-east. He wrote in his journal: "The natives last night saw an electric spark in the atmosphere, at which they appeared frightened, and one of them told them not to mention it as they would all be sick if they did...the natives of Cape Portland call it noi.hee.ner". He also referenced the word in October 1837 on Flinders Island, noting it as no.hoi.ner.

"The original sounds of the word are captured in the standardised spelling system of *palawa kani* as 'nuyina'," Ms Allan said.

"The use of the word honours Tasmanian Aboriginal language and its continuing adaptations over hundreds of years to new circumstances."

The name also connects the new ship with several Australian Antarctic ships named after the southern lights. Sir Douglas Mawson's ship, used for the first Australian-led expedition to the Antarctic in 1911, was the SY *Aurora*, while our currently serving icebreaker is the RSV *Aurora Australis*.

Focus now turns to construction of the ship, which began with a steel cutting ceremony in Romania in late May, followed by a keel laying ceremony in August.

The ship is being built by the Damen Shipyards Group in Galati, Romania, a leading shipbuilder with experience constructing scientific, hydrographic, naval, and ice class ships.

Australian Antarctic Division Modernisation Program Manager, Rob Bryson, said the steel cutting was the first tangible step of the ship build.

"Steel cutting involves the use of computer-controlled high-energy cutting machines, which use a combination of laser and plasma technology as well as high-pressure water to slice up large pieces of plate steel, which can be up to 130 mm thick," Mr Bryson said.

"These first pieces of steel will start to form the base of the ship, and are one of 57 blocks, some weighing around 300 tonnes, to be put together to form the icebreaker over the next two years of construction."

During the keel-laying ceremony in August, maritime tradition was observed with a silver 50 cent piece (newly minted by the Royal Australian Mint), welded on to the keel by the Australian Antarctic Division's Director, Dr Nick Gales.

Coins from Romania, Holland and Denmark were also welded alongside the Australian coin in recognition of each country's contribution to the design and construction of the ship. The coins will remain in place for the life of the ship, while duplicates will be placed on the bridge of the ship.

1. *The RSV* Nuyina *will transport expeditioners and supplies between Australia and Antarctica for the next 30 years. (Photo: Damen/DMS Maritime/Knud E. Hansen)*

"The keel laying is the first major milestone in the construction of this 160 m ship, which will carry scientists and supplies to Antarctica for decades to come," Dr Gales said.

"According to maritime tradition, attaching coins to the keel brings fair winds, speed and good luck.

"The four coins acknowledge that the original concept for ship was developed by a Danish company, the design and construction is being managed by a Dutch company, and the icebreaker is being built in Romania."

More than 5000 tonnes of steel has been cut so far, roughly half the vessel steel weight, and construction has now moved into the dry dock where the keel was laid.

The icebreaker is the centrepiece of the *Australian Antarctic Strategy and 20 Year Action Plan* launched in April 2016. The ship will arrive in its home port of Hobart in 2020 and make its maiden voyage to Antarctica during the 2020–21 season.

Read more about the ship at http://www.antarctica.gov.au/icebreaker.

WENDY PYPER and ELIZA GREY
Australian Antarctic Division

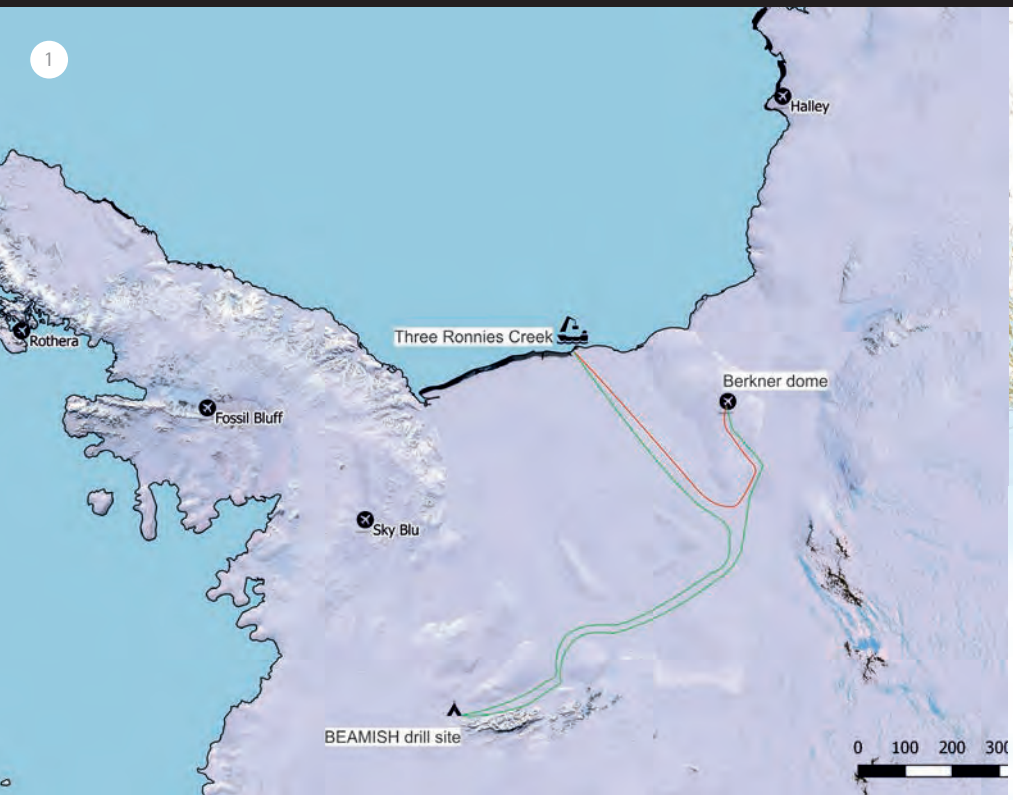
2. Secondary school winners of the Name Our Icebreaker competition from St Virgil's College, Hobart, with Department of the Environment and Energy Minister, the Hon Josh Frydenberg MP. (Photo: Glenn Jacobson)

3. The coins prior to being welded to the keel of the RSV Nuyina *– including the Australian 50 cent piece bearing the Commonwealth Coat of Arms on the reverse, and the profile of Queen Elizabeth II on the obverse [second from left]. (Photo: Damen/AAD)*

4. Primary school winners of the Name Our Icebreaker competition, from Secret Harbour Primary School in Western Australia, try out their Antarctic clothing. (Photo: Sally Chambers)

5. The first block of steel under construction in the shipyard. (Photo: Damen/AAD)

Traversing Antarctica



Travelling in a tractor and sled convoy across a frozen, near-featureless landscape, at 11 kilometres per hour for some 50 days, is not everyone's idea of fun.

But according to Australian Antarctic Division Traverse Systems Lead Project Officer, Anthony Hull, it can be rewarding, even when personal space is at a premium and comforts come Antarctic style.

"I spent 51 days without a shower, with three other blokes in one shipping container, and sometimes our toilet was a drum on the back of a sled. But it was one of the best experiences of my Antarctic career," Mr Hull said.

Just as well, because for many Antarctic programs it's the best way to haul tonnes of fuel, food and equipment between stations and field camps, or deep inland – opening up the continent to new scientific research opportunities.

Up until the early 2000s Australia had some 40 years' experience undertaking such 'heavy traverses', largely to support glaciological research. These included traverses inland of Casey in the 1970s, six year-long traverses in Wilkes Land in the 1980s, and traverses around the Lambert Glacier Basin between 1989 and 1995.

Now with the Australian Government's commitment to lead an international quest to drill an ice core containing million-year-old ice, deep in Antarctica (see side bar), the need for Australia to reinvigorate its heavy traverse capability is critical.

"The million year ice core project will be our first traverse 'customer' in 2020," Australian Antarctic Division Traverse Systems Project Manager, Matt Filipowski, said.

"For this and future projects over the 20 year life cycle of the traverse, we need to be able to travel more than 1000 kilometres inland to sites of scientific interest, hauling infrastructure, food, fuel and scientific equipment that will allow us to establish a mobile field station, which can be resupplied by traverse or by air."

With this ambition in mind, Mr Hull and fellow traverse project officer Steve Macaulay, joined the British and French traverses, respectively, during the 2016–17 Antarctic season, to study the different traverse technologies and methodologies employed by each program.

"We had a range of topics to investigate, including the types and numbers of prime movers and sleds used, power generation, fuel transport, occupational health and safety, mobile station infrastructure, and the interface of the traverses with ships and aircraft," Mr Hull said.

The two countries' traverses use quite different models, due mainly to the "logistical pathway" (aircraft or ship) used to deliver supplies to Antarctica, and the terrain that's crossed.

1. *Anthony Hull joined the British Antarctic Program on two traverses, from Beamish to Berkner Dome [994 km] and Berkner Dome to Three Ronnies Creek [785 km]. (Image: British Antarctic Survey)*

2. *Steve Macaulay undertook two 24-day traverses with the French Antarctic Program, between Dumont d'Urville and Concordia. (Image: AADC)*

3. *Anthony Hull on traverse with the British Antarctic Survey. (Photo: BAS).*

"The British model has strong links to an aviation platforms and is a bit like a 'roadhouse' – serving as a mobile fuel station and hard shelter for their twin otters and deep field science programs," Mr Hull said.

"The French traverse is mainly set up to resupply the French-Italian station, Concordia, at Dome C, about 1250 kilometres from their coastal station Dumont D'Urville. It's more of a logistical freight operation, transporting cargo and fuel from their resupply ship into Concordia, and bringing out heavy equipment and waste."

Mr Hull spent 71 days with the British Antarctic Program, with 51 days on traverse. In that time he participated in two traverses; 994 kilometres between Beamish and Berkner Dome, on the Antarctic Peninsula, and 785 kilometres between Berkner Dome and Three Ronnies Creek. Only 14 of these traverse days involved driving, with the rest of the time spent building berms to winterise equipment at scientific research sites, digging out buried fuel drums, decommissioning camps and grooming ski-ways.

Mr Hull said the traverse sleds were manually packed with components tied down with straps, rather than using containers. The relatively flat, smooth route between field sites also meant they could use 'polysleds' that look like large plastic tarps, rather than sleds on skis.

"It took the team up to three days to prepare and build one packed sled and during the traverse we would stop every three hours to refuel the prime movers and make sure all the straps were tensioned," Mr Hull said.

"The polysleds offer less surface drag, so it meant we could pull heavier loads. We hauled approximately 90 tonnes on our second traverse, using three Pisten Bully snow groomers.

In contrast, Mr Macaulay spent 110 days with the French team on two traverses between Dumont D'Urville and Concordia. Each 2500 kilometre-return trip involved about 24 days of driving (about 100 kilometres per day), with another 63 support days.

"The route to Concordia is like a highway that the French traverse two or three times a season. The terrain is undulating and covered in sastrugi, so a tractor at the front clears the route and a snow groomer tidies it up," Mr Macaulay said.

The traverses consisted of six tractors, with pairs of tractors joined by ropes. Each paired tractor system pulled eight to 10 sleds, carrying containerised loads of about 150 tonnes.

"Unlike the British polysleds, the French use sleds with solid axles like trucks," Mr Macaulay said.

"Smaller sleds carry 20 foot containers, aviation fuel and tanks, and larger sleds carry either two 20 foot containers or a single 40 foot container."

While the days were long and routine, Mr Macaulay said he enjoyed the quiet time alone in his tractor.

4. Packed sleds and polysleds on the British traverse to Berkner Dome. It took up to three days to pack one of these sleds. (Photo: Anthony Hull)

5. Steve Macaulay [left] on traverse with the French team, alongside fellow Australian Eddy Kontelj, Managing Director of heavy machinery company Williams Adams CAT. (Photo: Eddy Kontelj)

6. The French traverse arrives at Concordia station – visible at top right of photo. (Photo: Steve Macaulay)

"You start the tractor in low gear and once you reach a predetermined gear and speed you can literally put your feet up until you stop," he said.

"So long as nothing breaks and you keep the tractor on the road, you can let your mind wander."

At the end of the day everyone had a job to do to prepare the traverse for an overnight stop. They then retired as a team to eat pre-packaged meals prepared by the traverse doctor. Fortunately, the food was based on French cuisine, with plenty of cheese, cream, butter and pastries, high in the calories the hard-working team required.

While final decisions are yet to be made, the Australian traverse capability will need to move similar cargo and total tonnes as the French traverse model – given the equipment required to establish a mobile inland station and associated ice coring field camp, and the location of the likely ice core drilling site near Dome C, not far from Concordia station.

Whatever the traverse model, one thing is certain. The new capability will be a whole lot faster, more efficient, and more comfortable than traverses of yore.

"We used to use heavy, steel-tracked bulldozers that could bump along at about seven kilometres per hour" Mr Filipowski said.

"Now we can move almost twice as fast on more comfortable rubber tracks, using modern GPS navigation and carrying much bigger loads."

WENDY PYPER
Australian Antarctic Division

Million Year Ice Core

Australia is gearing up to lead an international project to drill an ice core in Antarctica containing a one million year record of the Earth's climate.

Antarctic ice cores contain chemical constituents such as carbon dioxide, sulphur, sea-salt and dust, which provide crucial information on past climate and climate processes. This information is key to understanding current climate and predicting future change.

A one million year record is significant because it spans a time in Earth's history when ice age cycles shifted their pacing from 41 000 years duration to 100 000 years duration. While we don't know what caused this shift, an ice core covering this period would allow scientists to extract a direct record of carbon dioxide and see what role, if any, it may have played.

Australia's contribution to international geophysical surveys across the region has helped narrow the location of ice that is likely to contain a one million year climate record – with a leading prospect near Dome C. This location needs to have thick ice with fine annual layers and be free from melting at the base from geothermal heat.

Australian Antarctic Division Deep Ice Coring Systems Lead Project Officer, Mr Al Elcheikh, said it was likely Australia and a European team would lead two drill operations near this location.

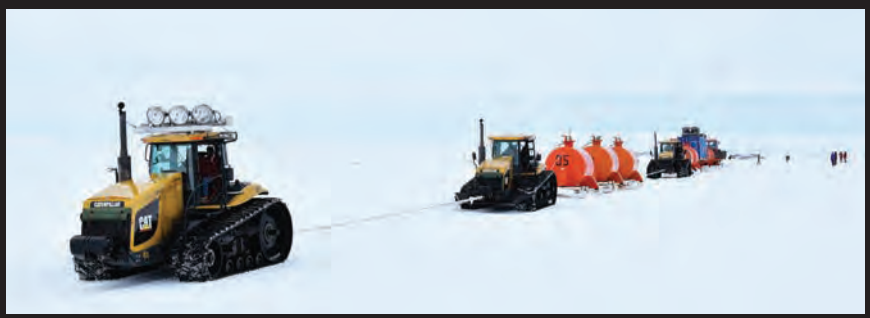
"We're working with our European collaborators to model the best locations for drill sites and to build the drills required," he said.

The first traverse in support of the Australian component of the project is expected to occur in the 2019–20 season (see main story), with delivery of much of the mobile station and drill camp infrastructure and equipment. This will include an ice core drilling shelter, core storage and drill workshop facilities, and accommodation for up to 16 people, about half of which will be ice core drilling personnel.

In 2020–21, science personnel will set up the drill and associated infrastructure in preparation for the start of a three to four year drilling program the following year.

"We anticipate there will be seven or eight people working two 8–9 hour shifts on the drill," Mr Elcheikh said.

"We aim to drill about 150 metres per week, so over a field season of 6–8 weeks, depending on logistical factors, we hope to drill between 900 and 1200 metres of ice core in each full season. This will produce between 6.5 and 8.5 tonnes of ice core a year, which we'll transport to the ship using the traverse."



Australia is reinvigorating its traverse capability to support the million year ice core project and future deep field projects. To facilitate this, Australian personnel went on a fact-finding mission with the French (pictured) and British traverses last season. (Photo: Steve Macaulay)

Antarctic cargo flies further with mid-air refuel

The first mid-air refuelling of a heavy-lift C-17A aircraft, high above the Southern Ocean, enabled a pre-season airdrop of supplies to Davis research station in September.

The refuelling of the C-17A, completed by a KC-30A 'Multi-Role Tanker Transport', enabled the Royal Australian Air Force (RAAF) to parachute nine tonnes of telecommunications equipment, food, medical supplies and mail on to the sea ice near the station.

Australian Antarctic Division Future Concepts Manager, Mr Matt Filipowski, said the flight was the final phase in a "proof of concept" to deliver supplies to Antarctica outside the summer shipping season, and extend the reach of aircraft in the Australian Antarctic Territory.

"Last year we completed our first mid-winter airdrop of supplies to Casey research station and our first remote airdrop of fuel to the Bunger Hills in support of a science project," Mr Filipowski said.

"The mid-air refuelling has allowed us to extend this capability to Davis, which is a further 1400 km from Casey and about a 10 000 km round-trip from Hobart.

"In the future, this capability will allow us to pre-position equipment and supplies for station and science projects, to all our Antarctic stations and deep inland, before the shipping season starts."

Flight Lieutenant Justin McFadden, who captained the C-17A during the airdrop, said that while air-to-air refuelling was a standard procedure for the RAAF, this was the first time it had occurred over the sub-Antarctic region.

"We refuelled about three hours into the flight at an altitude of 22 000 feet and a speed of 500 km per hour. This allowed us to continue the remaining four hours to Davis for the airdrop and return to Hobart," Flight Lieutenant McFadden said.

"When we neared the drop zone we descended to 5000 feet and slowed to about 270 km per hour, and deployed 15 pallets of cargo in padded containers, each weighing about 700 kg."

Prior to the C17-A's arrival, Davis Station Leader, Kirsten le Mar, and her team prepared a 1.5 x 1 km drop zone.

"The sea ice was about one metre thick, which is above the minimum 60 cm required to drop this weight of cargo," Dr le Mar said.

"We used a forklift to load the containers on to a sled, then towed it back to station for unpacking.

"We're now enjoying some fresh lemons and potatoes, and reading letters from home."

The airdrop capability will now be integrated into the Antarctic Division's standard operating procedures.

WENDY PYPER and NISHA HARRIS
Australian Antarctic Division

1. *Nine tonnes spread across 15 pallets were dropped from the Royal Australian Air Force C-17A. Parachutes are collected and reused after each airdrop. (Photo: Barry Becker)*

Cool cloud study

Ships, aircraft and satellites will be engaged in an ambitious, international campaign this summer, to better understand and model Southern Ocean clouds for climate and weather forecasts.

More than seven tonnes of atmospheric instruments will traverse the Southern Ocean on a specially strengthened deck of the *Aurora Australis*, monitoring clouds and aerosols (which contribute to cloud formation), between October and April.

Within that time, United States researchers will also overfly the Southern Ocean in the 'NSF/NCAR HIAPER'# Gulfstream V research aircraft, using on-board atmospheric instruments to collect data from above, below and within clouds.

These ship and aircraft observations will be combined and compared with surface-based measurements from Macquarie Island, and remote sensing data from satellites.

Altogether, the *Southern Ocean Clouds, Radiation, Aerosol Transport Experimental Study* (SOCRATES) aims to gain deeper insights into how clouds form over the Southern Ocean, what they're made of, and how they affect the atmospheric energy balance in the region (heat coming into the atmosphere versus heat going out).

Australian Antarctic Division atmospheric scientist, Dr Simon Alexander*, said data collected during the project will be used to evaluate and improve how clouds are represented in climate models.

"In most climate models the Southern Ocean sea surface temperature is too warm – so too much sunshine is getting through and warming up the ocean," he explained.

"That's because some climate models are getting the altitude and thickness of some clouds wrong, due to uncertainties and biases in the simulation of clouds, the aerosols that contribute to their formation, and air-sea interactions."

Current knowledge of Southern Ocean clouds relies almost entirely on satellite data. However, satellites struggle to resolve low-level clouds and there is a higher frequency of "super-cooled water clouds" above the Southern Ocean, compared to oceans in the Northern Hemisphere.

As their name suggests, super-cooled water clouds remain as liquid water at temperatures well below freezing. As the composition of clouds – how much ice or water they contain – affects how they scatter sunlight, understanding the occurrence and internal structure of different cloud types, and the factors that lead to their formation, is key to resolving modelling issues.

This summer the *Aurora Australis* will carry instruments to monitor clouds and aerosols. Aerosols influence cloud formation and composition by acting as 'nuclei' on which cloud droplets and ice particles can form.

"The high frequency of supercooled liquid water clouds over the Southern Ocean, may be due to low levels of dust and aerosols (due to less pollution) that can serve as ice nuclei, so the clouds remain as liquid water," Dr Alexander said.

"The presence of ice or liquid affects cloud 'albedo' – the ability to reflect light – which could be the reason for radiation biases in models."

1. *Super-cooled water clouds remain as liquid water at temperatures well below freezing. The southern hemisphere has a higher frequency of super-cooled water clouds than the northern hemisphere, possibly due to fewer pollutants and dust that can form ice nuclei. (Photo: Wendy Pyper)*

2. *Scientists on board the NSF/NCAR HIAPER Gulfstream V aircraft studying real-time data collected by the aircraft's cloud radar. (Photo: © NCAR/EOL)*

The ship will also carry a cloud lidar, which uses laser pulses to measure light scattered off cloud water droplets or ice particles. This will provide information about the composition and height of the clouds, while a cloud radar and microwave radiometer will provide information on cloud thickness, height and their liquid and ice water content. A micro rain radar and a specialised marine precipitation sensor will more accurately measure precipitation over the oceans, while avoiding contamination from sea spray.

Similar instruments will be carried by the CSIRO's RV *Investigator* at ice-free Southern Ocean latitudes for six weeks in early 2018.

While the ships are at sea, the United States' National Science Foundation has funded a campaign to fly their instrumented Gulfstream V out of Hobart for six weeks, starting in mid-January 2018.

Those on-board may be in for a bumpy ride, as the aircraft flies in a saw-tooth pattern through the ever-present cyclones that occur above the Southern Ocean.

A particular focus will be on the cold sector (post-frontal) regions of these cyclones, where mixed phase (water and ice), and super-cooled liquid clouds predominate.

"There will be about 16 flights and they will provide detailed information on the thermal and physical properties of different clouds," Dr Alexander said.

"A number of the flights will occur at the same time as the ships are traversing the ocean.

"This work will help us to determine how accurate satellite measurements are, calibrate them accordingly, and then extend these results to the whole Southern Ocean."

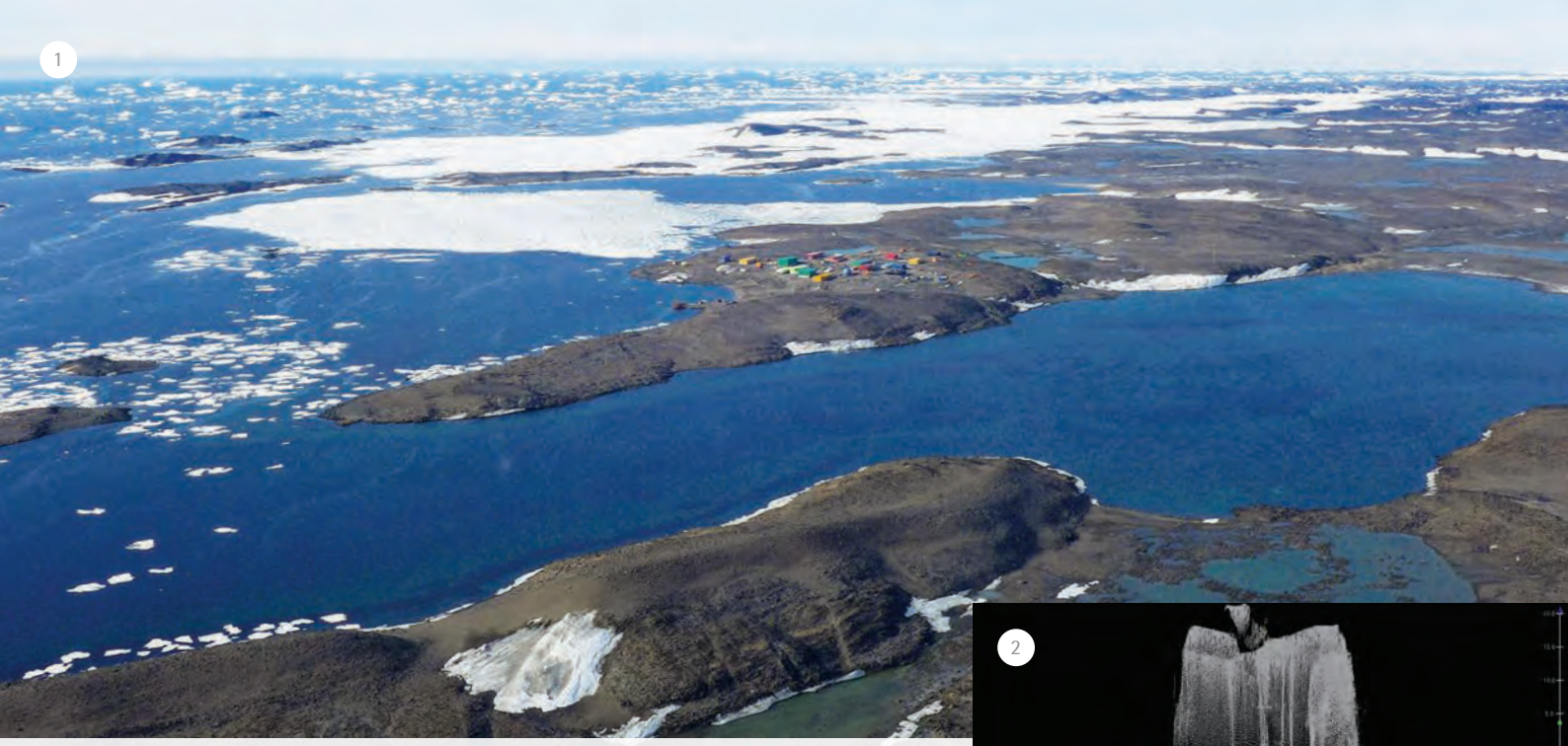
The research will feed into climate models to reduce errors in the simulation of Southern Ocean clouds, aerosols, air-sea interactions, precipitation, light reflectance from sea ice, and the region's heat balance. This will have flow-on effects for evaluating and improving global weather and climate forecasts in the high southern latitudes.

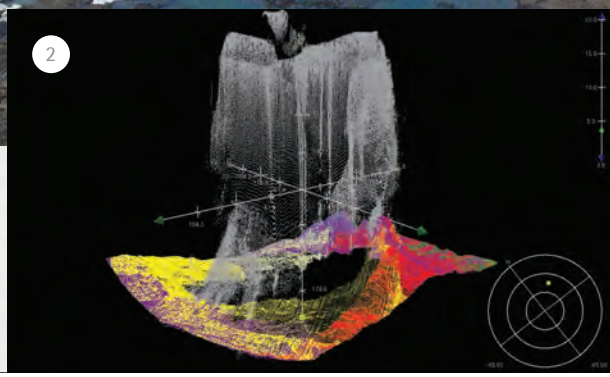
WENDY PYPER
Australian Antarctic Division

3. The NSF/NCAR HIAPER Gulfstream V aircraft is a cutting-edge observational platform that will use on-board instrumentation to study mixed-phase clouds (ice and water) and super-cooled liquid clouds over the Southern Ocean this summer. (Photo: ©NSF)

The 'High-Performance Instrumented Airborne Platform for Environmental Research' (HIAPER) Gulfstream V aircraft is owned by the National Science Foundation (NSF) and operated by the National Center for Atmospheric Research (Photo: NCAR).

* Dr Alexander is contributing to SOCRATES through Australian Antarctic Science projects 4292 and 4387.





1. *A large linear moraine [foreground] at the mouth of Heidemann Bay, similar to the one mapped offshore and under about 50 m of water. (Photo: Jodie Smith).*

2. *A multibeam sonar image of a large iceberg grounded near Davis station. The coloured dots represent the seafloor and the grey dots represent the iceberg. This particular iceberg is grounded in 120 m of water and is approximately 300 x 100 m in size and over three million tonnes in weight. (Image: Geoscience Australia)*

Iceberg Alley – what lies beneath?

Davis research station is renowned for its view of 'Iceberg Alley', where hundreds of icebergs sit, seemingly unchanged, year after year. Now, seabed mapping by a team of scientists, hydrographers, engineers and coxswains, has found that a barrier of shallow underwater banks prevent these frozen sentinels from setting sail.

During the 2016–17 Antarctic summer, a team from Geoscience Australia, the Royal Australian Navy and the Australian Antarctic Division undertook a comprehensive hydrographic and seabed mapping survey in the waters adjacent to Davis research station and along the coast of the Vestfold Hills. The work was conducted as part of a collaborative project between the three organisations, which aims to map and characterise the seabed of the nearshore environment adjacent to Australia's stations.

The project builds on previous work conducted at Davis in the 2009–10 season and at Casey in 2013–14 and 2014–15 (*Australian Antarctic Magazine* 27: 6-8, 2014).

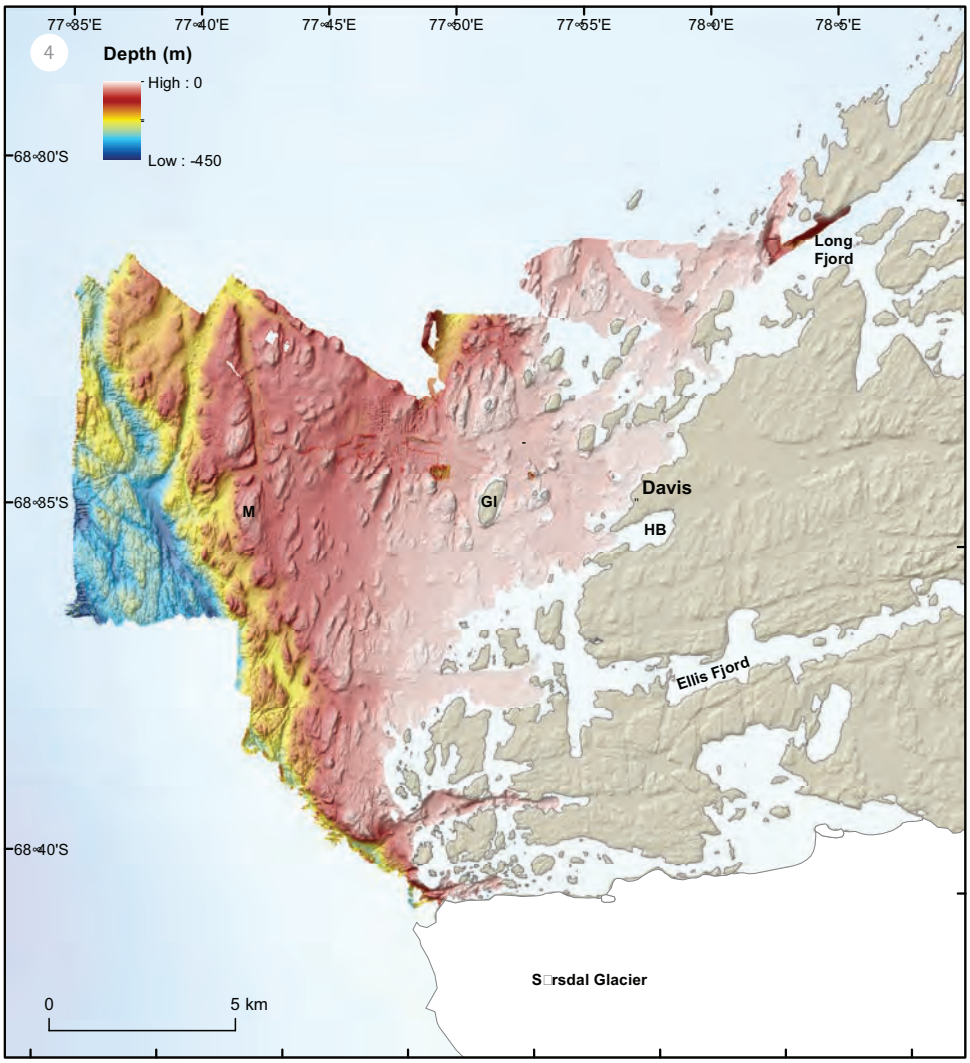
Using multibeam echosounders and sub-bottom profilers, which use sound to visualise the shape and depth of underwater features, along with sediment grabs and underwater cameras, the team now have a detailed picture of what the seabed off Davis looks like, and its geology and biology. This information will be used to understand the geological history of the area, including modern sediment processes, as well as the influence it has on marine life. The new data also help explain the presence of the spectacular icebergs sitting in Iceberg Alley.

The main aim of the project is to obtain bathymetry (depth) data to compile nautical charts for navigation and safety of life at sea. However, the baseline geoscience data can be used for many other applications. For example, the data is used to assist decision-makers responsible for developing environmental management strategies, including Marine Protected Areas, scientific studies on oceanography, paleoclimate, biodiversity, and ice sheet dynamics, meeting international obligations such as International Hydrographic Office and Antarctic Treaty System protocols, and aiding effective logistical operations.

The nearshore waters around Australia's Antarctic research stations are of interest because they are high-use areas. Davis is visited twice per year by Australia's icebreaker, *Aurora Australis*, and hosts frequent international visitors, such as the Chinese ship *Xue Long*. There are also numerous small boat operations in the area. Yet there are large areas of uncharted waters and these are often very shallow – as protruding rocks reveal. It is also an important biological site and key habitat for birds and mammals, with numerous penguin colonies, seal haul-out sites, and seabird nesting sites.

While these types of surveys have been done by Geoscience Australia and the Navy in the past, this was the first time such as survey was conducted using two workboats operating in tandem. This allowed the survey team to achieve maximum survey coverage during the short field season, and also meant that the boats could act as Search and Rescue watch for each other, allowing the survey team to go further from station than before.

The main focus area for the survey was the shipping channels coming into Davis, as well as Ellis and Long Fjords (see map). Previous work has identified a number of interesting features in these areas, including unique habitats such as polychaete (marine worm) reefs in the mouth of Long Fjord and high



suspended sediment loads in front of Ellis Fjord. It was also thought that these areas offered the best possible location to identify glacial features that would provide insight into ice dynamics in the area.

Once underway, the teams covered a lot of ground (actually, a lot of seabed!). In 23 survey days the team acquired approximately 130 km² of multibeam bathymetry and backscatter data, 18 sediment samples, 25 camera deployments (co-located with sediment samples) and 33 km of sub-bottom profiles.

The bathymetry data reveal a picture of the seabed in incredible detail. Overall, the seabed environment looks remarkably similar to the terrestrial environment onshore in the Vestfold Hills. It is characterised by flat plains interspersed with hard shallow banks and sediment-filled basins, similar to the hills and lakes found onshore. The sub-bottom profiles reveal the basins are infilled with only a few metres of soft marine muds, and the plains are draped with a thin veneer of sediment, indicating there is little modern sediment input into these waters.

Throughout the nearshore area, and particularly to the west of Gardner Island, are numerous hard shallow banks. These banks vary in size and depth but they all sit proud of the surrounding seabed and often rise to within metres of the surface. These banks essentially form a barrier to icebergs passing through the area with the currents from the north. Larger bergs can get wedged against these banks for years, possibly decades, until they melt, roll and continue to move south. Some of the icebergs mapped in the 2009–10 season are still in the same location seven years later.

As the icebergs move across the seabed they leave scour marks in the soft sediment. These range from enclosed, rounded wallow marks 10–40 m diameter and one metre deep, through to meandering tracks up to one kilometre long, often in the direction of the prevailing local currents.

While the waters around Davis preserve few glacial features, the team mapped one large moraine (an accumulation of glacial debris) in approximately 50 m of water. The crescent-shaped moraine is 1.2 km long and about 50 m wide and five metres high, and sits on top of a shallow bank. It is similar in size and form to moraines found in the Vestfold Hills, including one at the mouth of Heidemann Bay (see photo).

Initial observations of the underwater video reveal a diversity of benthic marine communities across the survey region, including mixed macroalgae communities on the shallow banks, complex sessile invertebrates on the rocky slopes, and sparse motile invertebrates in muddy basins. More detailed data analysis will be undertaken to improve our understanding of the marine life in the area and its relationship with the seabed, including mapping the distribution of macroalgae communities that are commonly found on the shallow banks.

The survey was an exciting opportunity for the team to explore the uncharted waters around Davis and to find out what lies beneath Iceberg Alley.

JODIE SMITH

Geoscience Australia

3. Rocks exposed in the shallow waters near Davis station, with Iceberg Alley behind. (Photo: Jodie Smith)

4. The bathymetry data acquired in the nearshore waters of the Vestfold Hills near Davis station, including 130 km² of new data from the 2016–17 season, as well as the existing 42 km² data close to Davis from the 2009–10 season. GI: Gardner Island, HB: Heidemann Bay, M: moraine. (Image: GA/RAN/AAD)

Glaciologists explode ice shelf secrets

1. Dr Galton-Fenzi (yellow jacket) and his team install radar and GPS instruments on the Totten Glacier in 2016. The glacier receives about three metres of snowfall a year so the instruments were deployed on towers four metres high. (Photo: Hayden Henderson/HeliRes)

Antarctic scientists will return to the Totten and Sørsdal glaciers this season to continue their study of the fundamental processes driving ice shelf thinning (previously reported in *Australian Antarctic Magazine* 31: 18-19, 2016).

Dynamite is the tool of choice on the Totten Glacier this season, for Australian Antarctic Division ice-ocean modeller, Dr Ben Galton-Fenzi, and his team.

By creating small, controlled explosions beneath the ice surface, the team hopes to define the structure of the bedrock over which the glacier flows, and determine whether there is any sediment between the ice and the bedrock.

"Seismic surveys use sound waves generated by explosive or percussive forces, which reflect off different surfaces like bedrock and ice, revealing their shape," Dr Galton-Fenzi said.

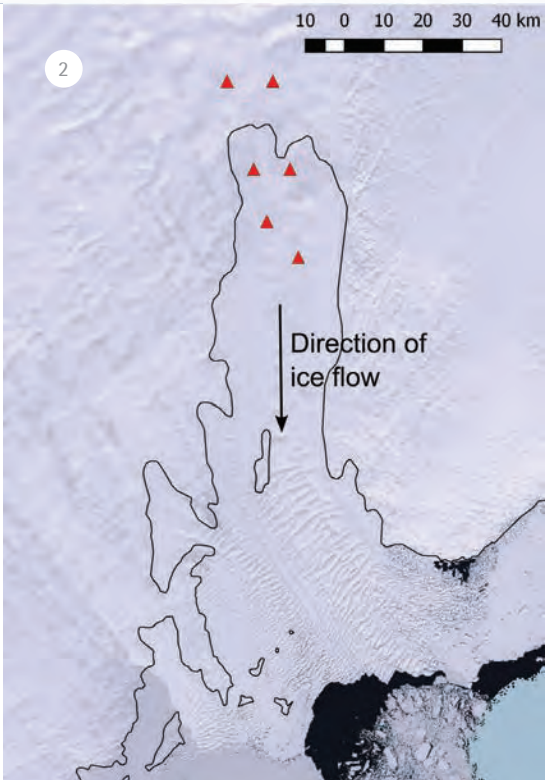
"The bedrock topography affects how the base of the glacier will melt once it reaches the ocean [where it becomes an ice shelf] and influences the rate of ice melt, while sediment can lubricate the passage of ice over the bedrock."

Recent research shows the Totten Glacier (near Casey research station) is susceptible to substantial amounts of inter-annual variability in the melting and flow of ice at its base. Deep channels in the bedrock under the ice could also allow warm ocean water to infiltrate the base of the glacier, increasing the risk of melting and sea level rise.

Dr Galton-Fenzi* said the seismic surveys will contribute to a broader investigation into how the flow regime of the Totten Glacier varies with time, the melt rates at its base, and how the ocean is driving melting.

Last year the team installed six radar and six GPS units along two of the Totten's glacial "flow lines". The radar units allow scientists to see the internal layers and base of the ice, and measure changes in ice thickness. The GPS measure the speed with which the ice is flowing towards the ocean, and changes in surface height.

"We used satellite imagery to identify the flow lines, which are surface features related to ice flow," Dr Galton-Fenzi said.



2. The location of radar and GPS instruments along two flow lines (six instruments per line) on the Totten Glacier. (Photo: Sue Cook)

"We deployed our instruments on the grounded part of the glacier, as well as the section where it begins to float, with each instrument about 20 km apart. One of the flow lines moves over a 'rumple' in the bedrock, beyond where the glacier begins to float, so it becomes grounded again. We want to see if the rumple affects how the ocean interacts with the glacier and, in turn, whether it affects melt rates."

This season the team will download nearly a year's worth of data from their instruments and leave them on the site for another year.

Their findings from both the instrument deployment and seismic survey will feed into representative models of the system, to improve the models and guide future research and instrument placement.

"The models represent the sum of our understanding of the system, so they're a powerful predictive tool," Dr Galton-Fenzi said.

"We've used them to identify the best location for our instruments to get the data that we need to test our hypotheses, and the results from the instruments are also used to refine the models."

3. The location of three surface lakes on the Sørsdal Glacier under investigation. The lakes are generally less than one metre deep and no more than 500 metres wide. (Photo: Jen Proudfoot)

4. The location of instruments deployed and seismic surveys conducted on the Sørsdal Glacier last season. Ground penetrating radar (GPR) looked at ice structure up to 60 m below the surface in the search for drainage channels. ApRES are radar instruments that measure ice thickness with millimetre accuracy, while GPS measure the speed of ice flow and changes in surface elevation. Seismic surveys using a hammer and plate system identify where the glacier sits on bedrock. (Photo: Sue Cook)

On the Sørsdal Glacier, near Davis research station, Dr Christian Schoof† of the University of British Columbia, Canada, will lead two teams of two people building on last season's work monitoring lake formation on the glacier's surface.

Dr Schoof and co-investigator Dr Sue Cook, of the Antarctic Climate and Ecosystems Cooperative Research Centre, installed radar and GPS units at various surface lake sites on the glacier last season, to measure ice thickness and ice flow speeds, as well as pressure transducers to record lake depth, and time-lapse cameras to monitor lake formation.

"In Greenland, lakes forming on the surface of the ice sheet are known to drain down to its base, changing how the ice sheet slides over the bedrock below," Dr Cook said.

"We want to test a similar theory in Antarctica – that surface meltwater ponding is occurring more frequently on outlet glaciers, and potentially reaching the bedrock and driving increased lubrication and acceleration of glacier flow."

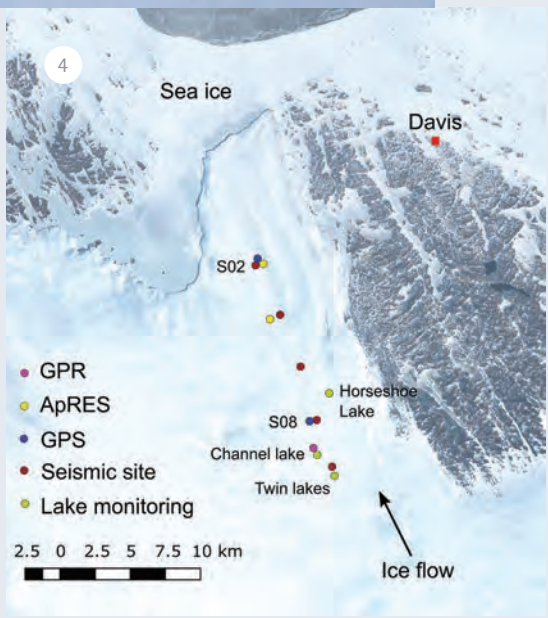
One lake of interest is Channel Lake, where water appears to drain below ground, before reappearing about five kilometres downstream. Last season the team used ground penetrating radar to try and map out the drainage pathway.

"We're not sure if all the water comes back to the surface or if some of it drains to the base," Dr Cook said.

To find out, this season the team will deploy six seismometers along the drainage pathway, to listen to the water flow. The instruments will pick up the sound of turbulent water movement, which scientists can then triangulate to reconstruct the drainage pathway.

The team will also run a 'tracer' experiment, adding salty water to the start of the drainage channel and using conductivity probes at the likely exit points to determine where and when it flows out.

"We observed an obvious line of surface features last year that we think were caused by drainage, so we will use these to position our tracer study," Dr Cook said.



"The time it takes for the salty water to reach the probes will provide information about what the drainage system looks like."

The team will also use a helicopter-based radar to fly over the glacier several times during the season, to look at meltwater formation, and to map out drainage pathways.

"Surface lake formation is more topical now in Antarctica because in future warming scenarios we expect the incidence of these phenomena to increase," Dr Cook said.

"The extra weight of surface water could lead to fracturing of the ice, which may have been a contributing factor to the recent calving of the one trillion tonne iceberg from the Larsen C ice shelf in July."

WENDY PYPER

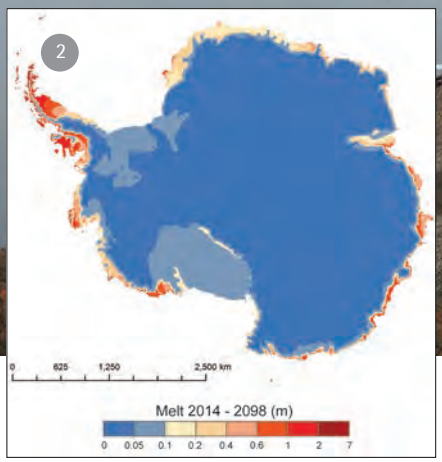
Australian Antarctic Division

* Australian Antarctic Science Project 4287

† Australian Antarctic Science Project 4342

Read more about the Sørsdal Glacier research in the team's blog http://www.antarctica.gov.au/science/climate-processes-and-change/the-antarctic-ice-sheet/srsdal-glacier-dynamics/srsdal-glacier-blog

Ice-free areas could expand across Antarctica



Ice-free areas in Antarctica could expand by close to 25 per cent by 2100 and drastically change the biodiversity of the continent, according to research published in *Nature* in June.

The study is the first to examine the impact of climate change on ice-free areas in Antarctica, which currently cover less than one per cent of the continent, yet are home to almost all the continent's flora and fauna.

Led by University of Queensland PhD student Jasmine Lee, and Australian Antarctic Division senior research scientist Dr Aleks Terauds, the research shows a warming climate will cause isolated ice-free areas to expand and join together.

"We predict that melt across the Antarctic continent will lead to the emergence of between 2100 km^2 (3 per cent) and 17 267 km^2 (25 per cent) of new ice-free areas by the end of this century," Dr Terauds said.

"While this could provide new areas for native species to colonise, it could also result in the spread of invasive and non-native species and the extinction of less competitive native species.

"The Antarctic Peninsula shows the greatest projected change, with more isolated impacts along the East Antarctic coastline."

Ms Lee said the research team used models to examine the impact of climate change on ice-free areas under two carbon dioxide emissions scenarios, adopted by the Intergovernmental Panel on Climate Change Fifth Assessment Report.

"By combining air temperature, solar radiation, projected precipitation changes and spatial information on current ice-free areas and ice coverage, we have quantified, for the first time, the potential impacts of climate change on ice free areas," Ms Lee said.

Permanently ice-free areas range in size from less than one square kilometre to thousands of square kilometres and are important breeding grounds for seals and seabirds. They are also home to small invertebrates, such as springtails and nematodes, and vegetation including fungi, lichen and moss.

Ms Lee said the findings of the study were especially important given the restricted distribution of many of these species, which are often only present in a single region across the continent, or even a single ice-free area.

"Geographic isolation and lack of connectivity has largely sheltered terrestrial Antarctic organisms from dispersing species and inter-species competition," she said.

"How they will cope with increasing connectivity and competition from invasive species is largely unknown. So understanding the effect of expanding ice-free areas is essential if we are to fully understand the implications of climate change in Antarctica."

Dr Terauds said the models of expanding ice-free areas could be used to help identify sites that should be protected, or to pinpoint high risk areas that would benefit from increased biosecurity to minimise alien species incursions.

ELIZA GREY and WENDY PYPER

Australian Antarctic Division

1. *Orange coloured lichen grows above an ice-free cliff in Marie Byrd Land, West Antarctica. (Photo: Jasmine Lee)*
2. *Ms Lee's and Dr Teraud's research found that under moderate and high carbon dioxide emissions scenarios, ice-free areas will expand by between three and 25 per cent. This image shows projected Antarctic ice melt by 2100 under the high emissions scenario. The world is currently tracking to warm by more than 2°C under this scenario. (Image: Nature 547: 49-54, 06 July 2017. doi:10.1038/nature22996)*

DNA reveals jellyfish a popular choice in albatross diet

Albatross have a taste for jellyfish, according to DNA evidence from their droppings.

Analysis of 1460 scat samples from eight sub-Antarctic breeding colonies of black-browed and Campbell albatrosses, found jellyfish DNA was present in 37% of the scats and made up 20% of the dietary DNA identified in those scats.

Seabird ecologist, Ms Julie McInnes, from the Australian Antarctic Division and Institute for Marine and Antarctic Studies, said scientists previously considered jellyfish an unlikely menu item.

"Past studies of albatross diets relied largely on analysis of their stomach contents, with jellyfish found in less than one in five samples, and then only in low amounts of around five per cent," Ms McInnes said.

"However, jellyfish are difficult to identify through stomach content analysis, because they are quickly digested and leave no 'hard parts', such as bones."

The new research* relied on a technique known as DNA metabarcoding, which enables the DNA of distinct groups of organisms to be identified within a scat sample.

The analysis identified six main prey groups, with bony fish the favoured prey item, followed by jellyfish, crustaceans and squid.

"Our results show that jellyfish are a common prey of adult black-browed and Campbell albatrosses and that they are fed to chicks," Ms McInnes said.

"We also found that the frequency of jellyfish occurrence in the diet was similar in years of high and low jellyfish abundance, suggesting that the birds may be actively targeting jellyfish."

The finding provides new information about the foraging ecology of the birds and will help scientists assess the health of the broader marine ecosystem into the future.

"The diets of top-order predators, such as seabirds, reflect changes in the availability of prey, due to pressures such as climate change or fishing," Ms McInnes said

"Warmer oceans and overfishing are predicted to favour jellyfish populations, so it's important to understand the contribution of these gelatinous organisms to the birds' diet.

"Any future monitoring programs that use diet data should employ methods that can detect all major prey groups, so that ecosystem changes can be observed," Ms McInnes said.

The research collaboration also included the Tasmanian Department of Primary Industries, Parks, Water and Environment, and a range of international institutions. It was published in *Molecular Ecology* in August.

WENDY PYPER

Australian Antarctic Division

*Australian Antarctic Science projects 4014 and 4112.

1. *A black-browed albatross feeds its chick on Steeple Jason Island in the Falkland Islands. Scientists were surprised to see jellyfish in the diets of chicks. Further research is needed to determine the impact of such a low nutritional prey on the birds over the long term.. (Photo: Julie McInnes)*

Boundary rider

Dr Bishakhdatta Gayen from the Australian National University (ANU) has been awarded the third RJL Hawke Post-Doctoral Fellowship* in Antarctic Environmental Science. Dr Gayen will use numerical simulations to investigate the small-scale physical processes occurring at the boundary between the Antarctic ice sheet and the ocean. His work will enable global ocean models to better represent these processes, leading to more accurate projections of current and future ice melt and sea level changes.

"The 'boundary layer' is everything."

New RJL Hawke Post-Doctoral Fellow, Dr Bishakhdatta Gayen, is referring to the millimetre-thick boundary where salt and heat from the ocean meets the base of the ice shelf around the Antarctic continent.

Salt, in direct contact with the basal ice surface, triggers ice melt by lowering the freezing point of water – just as salt on the road on a cold winter's day melts ice.

The fresh meltwater is often unstable and turbulent, producing tiny eddies (whirlpools of water) within the boundary layer, which are thought to boost melting by transferring heat to the ice surface from the surrounding ocean (see diagram).

These complex boundary layer dynamics and heat transfer processes are the focus of Dr Gayen's research over the next two years, with the aim of developing a simple mathematical relationship between melt rate and turbulence, which can be scaled up to represent ocean-wide processes in models.

"In ocean models the boundary layer is poorly represented and errors in this representation propagate all the way up to the measurement of ice melting and sea level change," Dr Gayen said.

"If you really want to know how the ocean affects ice sheet melting you have to understand it at the millimetre scale of the boundary layer, because this is the layer that affects melting first.

"If you can resolve this smallest scale, then the larger ones will automatically be correct."

To resolve this small scale Dr Gayen will attempt to define the boundary layer – the physics that create it and its physical characteristics, including thickness. To do this he will use a supercomputer to solve a series of mathematical algorithms that describe the movement of fluid, heat and salinity, building mathematical relationships between these characteristics that can then be used to predict ice melt under defined conditions.

Data generated by these ice melt simulations will be validated by experiments in the ANU's Geophysical Fluid Dynamics laboratory. Within a tank in the laboratory, a large block of ice will be placed in contact with salty water. The temperature, salinity and movement of the water can then be modified to test its effect on the melt rate of the ice and compare these results to the supercomputer predictions.

From this Dr Gayen aims to develop a "paramaterization" – a mathematical model representing the boundary layer.

"This paramaterization will be able to be scaled up in ocean models, to predict the rate of ice melt under different environmental conditions," he said.

1. *Dr Gayen's research will contribute to ice-ocean models for ice shelves and glaciers, such as the Totten Glacier (pictured) in East Antarctica. (Photo: Esmee van Wijk)*

2. *Australian National University geophysicist and RJL Hawke Post-Doctoral Fellow, Dr Bishakhdatta Gayen, aims to define the boundary layer between the ocean and Antarctic ice sheet, to improve ocean model estimates of ice melt and sea level changes. (Photo: Wendy Pyper)*

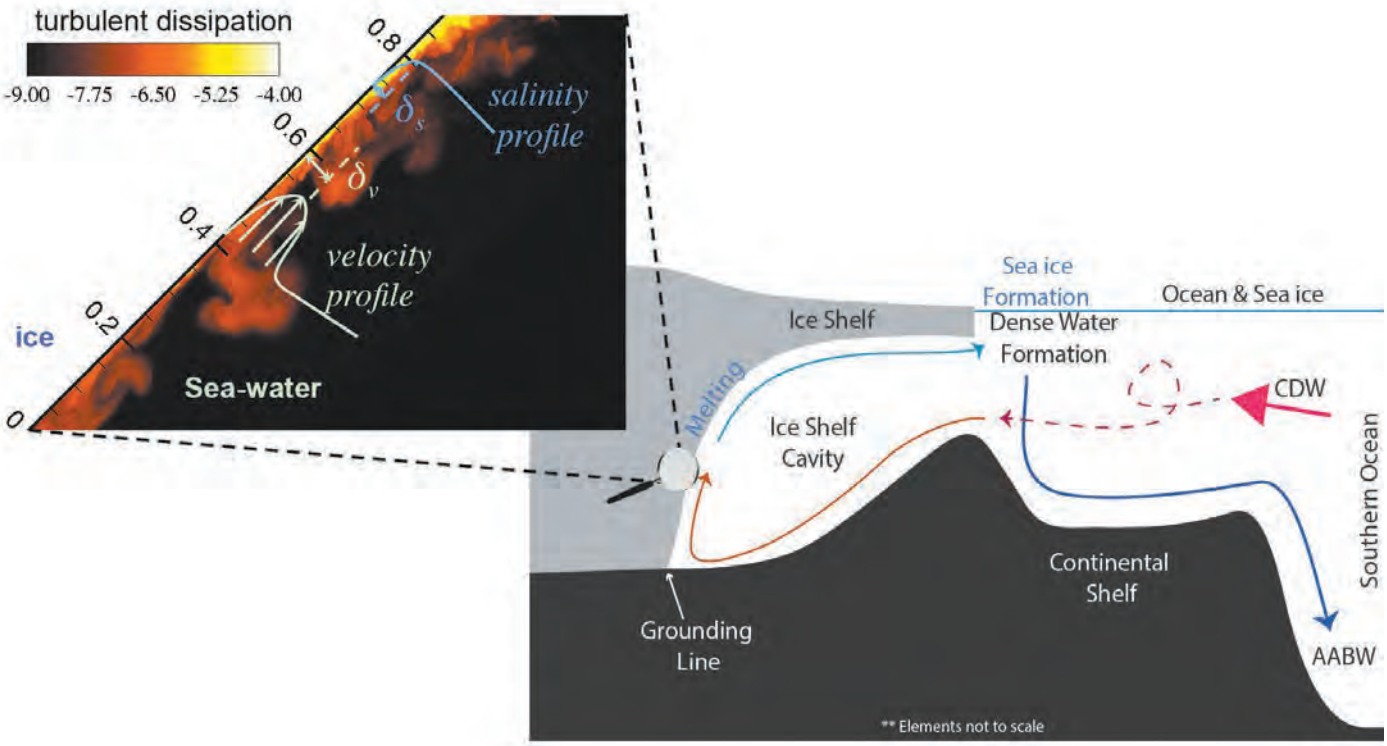


Figure: A schematic of the ocean circulation on the Antarctic continental shelf. Grounded ice sheets are buttressed by floating ice shelves. Their basal melting is driven by the supply of salt and heat from the Southern Ocean via Circumpolar Deep Water (CDW). This melting influences the formation of Antarctic Bottom Water (AABW) which drives ocean currents around the world.

The magnifying glass shows the location of the saline boundary layer. Eddies (red coloured whirlpools) created by fresh meltwater within the saline boundary layer can be seen circulating under the sloping ice shelf, drawing relatively warmer seawater to the ice boundary (the scale shows distance in metres along the slope). The strength of the eddies is provided in a log scale (stronger flows are in yellow and red). δs and δv are typical salinity and velocity boundary layer thicknesses, respectively. (Image: Bishakhdatta Gayen)

Dr Gayen will also test his paramaterization under different conditions that further drive ice melt. These include the slope of the ice shelf, and the effect of tides, currents, upwelling water and internal ocean waves (waves that oscillate horizontally and vertically within water masses).

Finally, Dr Gayen will be able to validate his paramaterization of the boundary layer, by assessing it against field observations obtained on the Amery Ice Shelf and elsewhere in Antarctica. On the Amery Ice Shelf, for example, scientists from the Australian Antarctic Division and Antarctic Climate and Ecosystems Cooperative Research Centre have run a multi-year drilling project, deploying instruments through boreholes in the ice to measure changes in ocean temperature, salinity, water movement and the melting of ice beneath the shelf (*Australian Antarctic Magazine* 31: 18-19 (2016).

"The Amery drilling program has measured the properties of the boundary layer next to the ice face. So we can feed those conditions and my paramaterization into ocean models and evolve them," Dr Gayen said.

"This work will provide a knowledge base for improvements in the representation of Antarctic processes in ocean models. This in turn will lead to more accurate projections of future Antarctic ice melt and sea level changes."

WENDY PYPER

Australian Antarctic Division

*The RJL Hawke Postdoctoral Fellowship was named in honour of former Australian Prime Minister Bob Hawke, acknowledging his contribution to protecting the Antarctic environment. The fellowship is awarded on the basis of scientific excellence for early career doctoral graduates to pursue policy-relevant science aligned to the Australian Antarctic Science Plan.

Size matters in Southern Ocean ecosystems models

Marine ecologist Rowan Trebilco, working within the Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC), received the second RJL Hawke Postdoctoral Fellowship in Antarctic Environmental Science in 2015. During his three year fellowship Dr Trebilco advanced development of size-based models, to help understand the role of 'mesopelagic'* fish and squid in shaping Southern Ocean ecosystems, now and in the future.

Southern Ocean ecosystems provide us with many things of value, from economically important krill and finfish fisheries, to charismatic megafauna, such as penguins, seals and whales, and smaller, yet (arguably) equally charismatic planktonic creatures. The Southern Ocean also provides valuable ecosystem services, like producing oxygen and sequestering carbon; around 40% of the global ocean's uptake of anthropogenic carbon is thought to occur in the Southern Ocean.

These values are fundamentally underlain by the movement of energy (and material) through food webs. A pressing question is: what impact will changing environmental conditions and patterns of human use have on the provision of these values and services? However, it is almost impossible to observe these processes directly across large scales. Instead, we need models that we can combine with observations, to build a picture of how things work and understand how they may change. No one model is perfect though – different models have different strengths, weaknesses, and gaps.

A solution is to have a 'toolbox' of different models. This helps ensure that gaps are filled, and if several different models tell the same story and are congruent with available observations, it provides confidence that the story is realistic. Meteorologists have been doing this for years, and models are at the point where we're pretty good at forecasting the weather in the short to medium term (something thought impossible not so long ago). We're just starting down this path in the field of ecosystem modelling.

At the ACE CRC we are developing such a toolbox of models for Southern Ocean ecosystems†, to better understand how they work, how they may change, and how they might be best managed under different scenarios of future climate and fishing. Contributing to this is a major part of my Hawke Fellowship and my role within the CRC.

A big gap in Southern Ocean ecosystem models (and ocean ecosystem models globally) has been the poor representation of mesopelagic fishes and squids. We know that mesopelagic fish are the most abundant vertebrates in the biosphere, and that they account for more biomass than any other group of fishes. We also know that mesopelagic fishes and squids are key prey for penguins, seals and other large marine predators. In fact, they provide a major alternative energy pathway (a route by which energy can move from phytoplankton to top predators, and be exported to deep water) to the better-understood, krill-dominated food chains. But detailed understanding of their ecology – their diets and what drives their distribution and abundance – and their relative importance in food webs, compared to krill, is lacking.

The overarching goal of my project for the Hawke Fellowship was to address this gap by developing size-based models to understand the role of mesopelagic fishes and squids in Southern Ocean ecosystems (*Australian Antarctic Magazine* 29: 8-9, 2015). Size-based ecological models differ from traditional species-focused approaches in that they focus on body size rather than species identity as the principle descriptor of an individual's role in a food web. This means that they can quantify and predict ecosystem structure and change without detailed species and stage-specific dietary data.

I've been fortunate to have several opportunities to connect this work with larger research initiatives nationally and internationally, which has helped broaden the scope and impact of the work.

In 2015-16 I participated in the design and planning of the Kerguelen Axis (K-Axis) voyage (*Australian Antarctic Magazine* 29: 2-3, 2015), then co-led the fish and squid sampling program at sea. During the voyage we sampled the mesopelagic community from the surface to 1000 m at 36 stations. The locations were chosen to maximise our ability to disentangle how key environmental drivers (such as sea ice, frontal features and water depth) drive ecosystem characteristics. At each station, the 'mid-water opening-closing' device we used on the net allowed us to split the catch into 200 m depth layers. At the same time, we used the ship's acoustic echosounders to build up a picture of how biomass was distributed in the water column.

We sorted and photographed the catch at sea, then froze everything for further processing and analysis on return to Australia. Since the voyage, we have been measuring all the individual fish and invertebrates (including squids) in the photographs. We are also analysing samples from individual fish to get information on food-web linkages (to see who is eating whom), using biochemical tracers such as stable isotope analysis of muscle tissue and genetic analysis of gut contents. This has yielded an incredible new dataset for fishes and squids that will inform the development of models and allow us to evaluate their performance. This dataset has also sparked new collaborations with colleagues in France, the UK, China and Japan.

1. *Dr Rowan Trebilco is developing size-based models of mesopelagic fishes and squids, to understand their role in the Southern Ocean and how they may be affected by fishing and climate change. (Photo: Ruth Eriksen)*

2. *Some of the incredible variety of fishes, squids and other invertebrates that live in the top 1000 m of the Southern Ocean. These animals are an important alternative food source (energy pathway) to krill, for higher predators. (Photo: Rowan Trebilco)*

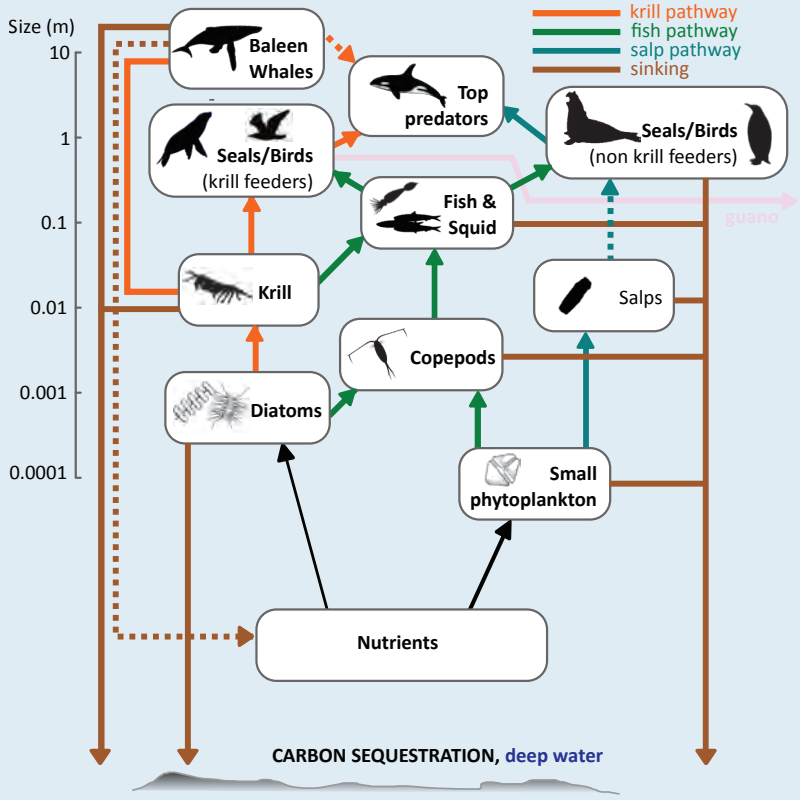
3. *A generic Southern Ocean food web showing the different energy pathways from primary producers (phytoplankton, diatoms) to higher predators. In the fish pathway, fish feed on smaller plankton and zooplankton and in turn are eaten by seals and seabirds. In the krill pathway, krill feed on diatoms and are in turn eaten by fish/squid, seals, seabirds and baleen whales. Salps are jellyfish-like organisms. Carbon in faeces and dead organisms sinks to the deep ocean. (Rowan Trebilco)*

While the original plan for my fellowship had been to focus only on mesopelagic fishes and squids, there was a lot of interest in extending the models to include zooplankton and higher trophic levels, such as seabirds, marine mammals and toothfish. To facilitate this I coordinated a group of experts to pull together information across these other trophic levels. Development of a model that includes these groups is currently underway.

In addition to local collaborations I've developed international partnerships. In 2016 I was awarded a Scientific Committee on Antarctic Research Fellowship to spend three months developing collaborations with two groups of colleagues in France.

The first group, at the Museum of Natural History in Paris, has been studying the natural history of mesopelagic fishes for many years, particularly on the Kerguelen Plateau. I worked with them to identify the fish we caught on the K-axis voyage, and determine how to best represent mesopelagic fishes in my models.

The second group at CLS (Collecte Localisation Satellites – a subsidiary of the French space agency), has developed a model (SEAPODYM) to understand how mesopelagic taxa move energy through the water column and make it available to higher trophic levels. This model was developed for tropical seas, with a focus on tunas, but there is clear potential for Southern Ocean applications.



Together we worked on a Kerguelen Plateau implementation of SEAPODYM, which will be incorporated into the ACE CRC ecosystem model toolbox, and will provide the foundation for a PhD student project next year.

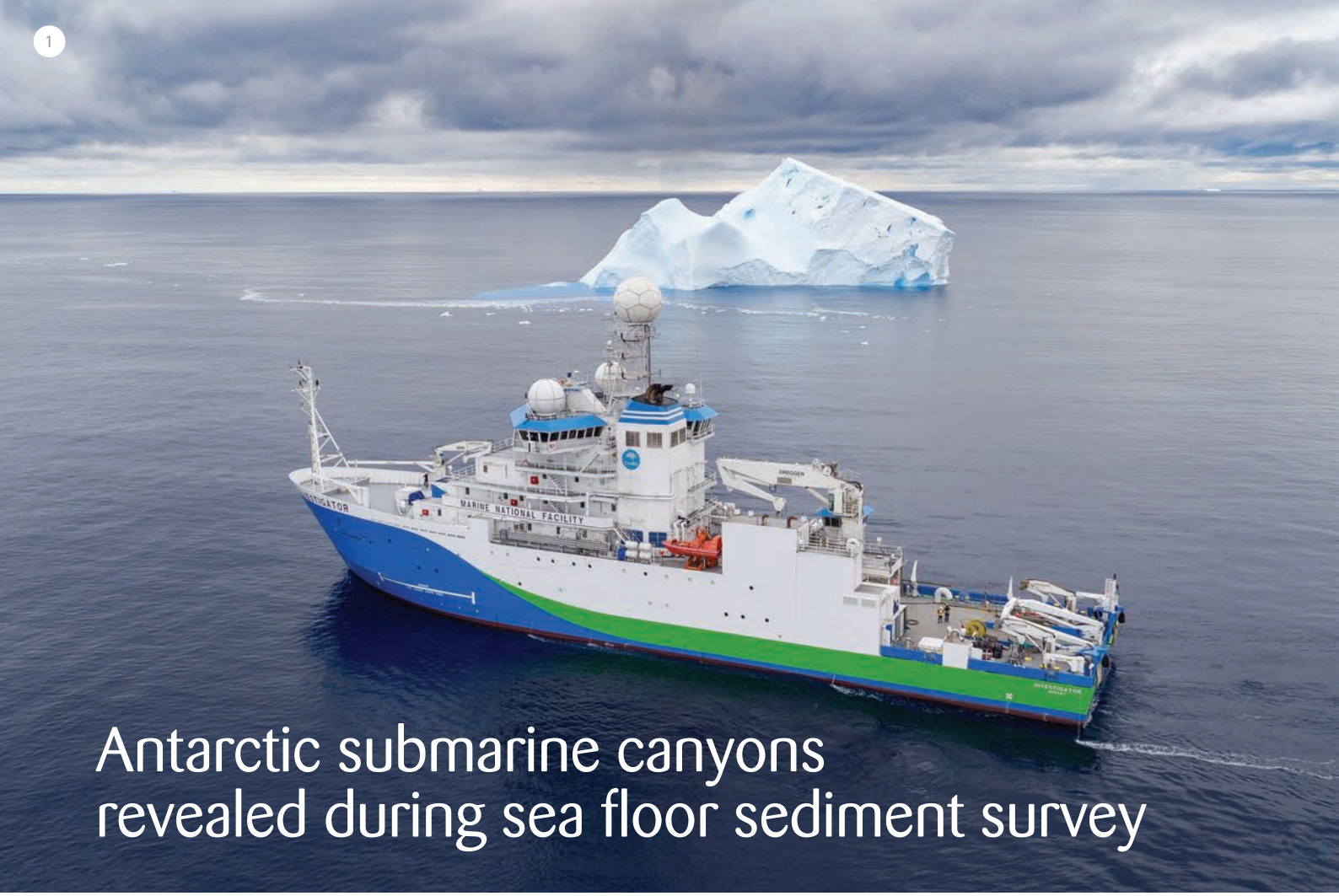
My time working at CLS also led to my inclusion on an EU-funded project called MESOPP (MEsopelagic Southern Ocean Predators and Prey; www.mesopp.eu). This project aims to develop standardised methods and datasets for assimilating estimates of mesoplelagic biomass from active acoustic data, in ocean ecosystem models. The size-based models I have been developing for the Hawke project will be one of three main groups of models used for this project.

The Hawke Fellowship has been an amazing opportunity to 'think big' and develop large, collaborative, long-term research projects. Much of this work is set to come to fruition over the next 6–12 months and it will substantially advance our understanding of how mesopelagic fishes and squids fit into Southern Ocean ecosystems, how they support key predator populations, and how things are likely to change into the future.

ROWAN TREBILCO
ACE CRC and UTAS

*The mesopelagic zone is normally defined as the top 200–1000 m of ocean.

†Australian Antarctic Science Project 4366



Antarctic submarine canyons revealed during sea floor sediment survey

Sediment samples collected on the Antarctic ocean floor are set to provide clues to past climate in East Antarctica and how the Earth's climate system works. At the same time, scientists have mapped a striking submarine landscape of canyons and sediment ridges along the Sabrina Coast of East Antarctica.

The Sabrina Sea Floor Survey voyage was conducted from the CSIRO's Marine National Facility RV *Investigator* between January and March this year. It covered 48 000 km^2 of the continental slope off the Sabrina Coast, close to the Totten Glacier, Moscow University Ice Shelf and Dalton Iceberg Tongue.

The project aimed to identify the former ice extent of the Totten Glacier, which is one of the most rapidly thinning glaciers in East Antarctica, and build a picture of climate evolution in the region. To do this, we decided to study sediment samples from the continental slope, because these sediments are less vulnerable to erosion by advancing ice.

The RV *Investigator's* multibeam echo sounders and sub-bottom profiler were used to find the best sediment deposits for climate records. These instruments use the returning echoes from pings of sound directed at the sea floor, to visualise and map sediment deposits. We also used a high resolution seismic reflection system to image beneath the sea floor.

While other surveys have visited the area, they only collected widely spaced soundings. In contrast, our multibeam echo sounders provided us with grid soundings of 50 to 100 m resolution over 48 000 km^2, while the sub-bottom profiler provided 4000 km of data.

Once target areas were identified, we sampled sediments using piston and kasten corers. The piston corer drives 10 cm wide tubes, up to 24 m long, into the sea floor. The kasten corer is a box-shaped tube, 15 cm across, with a one tonne weight on the top, which can recover larger volumes of surface sediment.

We retrieved 11 kasten cores from the top few meters of ridges and canyons, and six piston cores, each containing up to 16 m of sediment from ridges. In the kasten cores from the canyons we were surprised by an accumulation of diatoms. These microscopic plants live in the upper ocean and produce skeletons of silica. Sometimes sudden die-offs produce thick masses of diatoms on the ocean floor, but we've never seen it in submarine canyons.

The deep piston cores retrieved sediment comprised almost entirely of mud, with physical properties and fossil layers that suggest the cores will provide information on climate cycles going back 300 000 years. What it means for Antarctic climate history is not clear yet. We have a team of 62 researchers from five countries conducting a detailed analysis of the cores, but it will take some time to work through the hundreds of samples.

As well as suitable sediment deposits, our multi-beam echo sounders revealed a series of branching canyons near the Moscow University Shelf, originating on the upper continental slope and converging into several major canyons on the lower slope (see map). At the other (western) end of the study area, we found the topography dominated by ridges, separated by a single, relatively straight canyon.

Canyons are typical features of continental slopes around the world, but the sediment ridges are not common and these ones have great potential for recording the climate history of the Antarctic.

1. The Marine National Facility, RV Investigator, *on the Antarctic margin. (Photo: Doug Thost/MNF)*

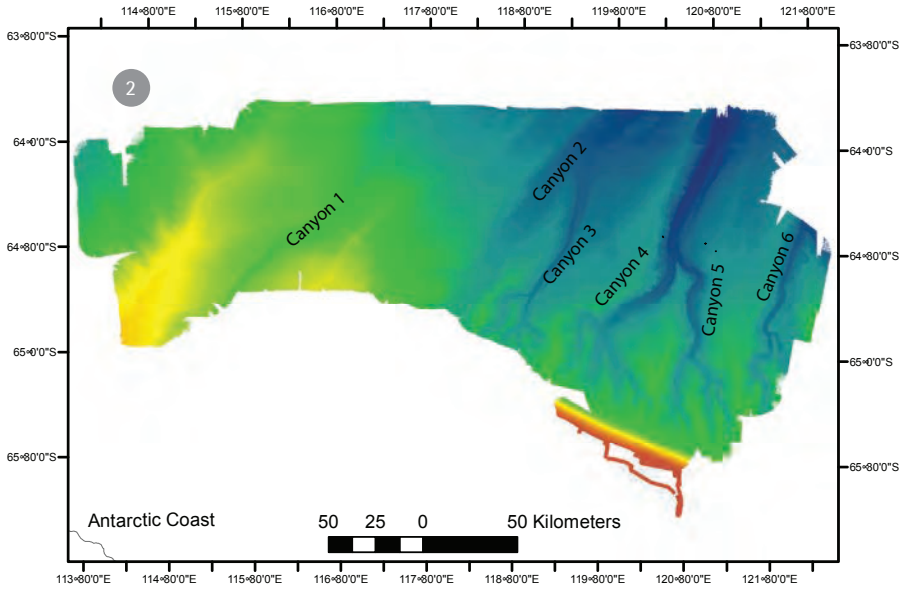
The western ridges are particularly unusual. They could be made up of mud dumped from the continent by the Totten Glacier, or they could be the result of a long-lived eddy in the ocean that has been acting as a sediment trap for mud moving along the margin.

The Sabrina Sea Floor Survey has provided a rich source of new scientific data that will take years to exploit. This shows that the RV *Investigator* has a lot to offer Antarctic marine research and it also shows the benefits that will flow from the new Australian Antarctic icebreaker, RSV *Nuyina*, which will have some of the same instruments.

PHIL O'BRIEN and LEANNE ARMAND*

Voyage Co-Chief Scientists,
Macquarie University

*Australian Antarctic Science Project 4333



2. *Multibeam bathymetry showing the mapped canyons off the Sabrina Coast. The branched canyons appear to the right (east), while over to the west the topography is dominated by ridges separated by a single canyon. (Image: MNF/Phil O'Brien)*

3. *The box-shaped kasten corer can recover large volumes of sediment. L-R: Jason Fazey (MNF) and Mark Lewis (MNF), Bradley Opdyke [Australian National University]. (Photo: Doug Thost/MNF)*

4. *Deploying the piston corer during the Sabrina Sea Floor Survey. (Photo: Leanne Armand/MNF)*

The Sabrina Sea Floor Survey was led by Leanne Armand and Phil O'Brien of Macquarie University, with participants from Istituto Nazionale di Oceanografia e Geofisica Sperimaentale (OGS) Italy, Australian National University, University of Granada, Spain, Colgate University, USA, University of Tasmania and Geoscience Australia. Australian participants were supported by an Australian Antarctic Science Grant and additional financial support was provided by the Australian Research Council, Italian Programa Nazionale Di Richerche in Antartide (PNRA), Spanish Ministry of Economy and Competitivity (MINECO) and the US National Science Foundation.

Powering pollution reduction

A new soil remediation technology, using small electric currents to reduce fuel contamination, will be trialled at Australia's Casey research station this summer*.

For more than a decade the Australian Antarctic Division's risk and remediation teams have been developing and refining approaches to cleaning up fuel spills, and contaminated soil and water, in the unique conditions of Antarctica (*Australian Antarctic Magazine* 27: 1-3, 2014).

Senior Remediation Scientist, Mr Jeremy Richardson, said the new electric technology is a form of "electrokinetic remediation".

"This involves inserting a number of electrodes into contaminated soil and pulsing a low voltage current through it, to break down hydrocarbon molecules and stimulate microbial activity," he said.

Electrokinetic remediation will be used on soil that has already undergone several years of active remediation in 'biopiles, as well as soil that hasn't undergone any processing.

"While this innovative technique has been used in warmer climates and the northern hemisphere, it has never been used in Antarctica, where the soil conditions are unique and microbes may react in different ways," Mr Richardson said.

Remediation Project Manager, Mr Tim Spedding, said the biopiles work had shown indigenous Antarctic microbes can break down the hydrocarbons when the soil is carefully managed in the soil mounds.

"We have already been able to reduce contamination from 5000 parts per million to around 500 ppm, which is the first time bioremediation of bulk quantities of contaminated soil has been successful in Antarctica. Now we want to see if we can get those concentrations down even further," Mr Spedding said.

The question of how low the residual fuel concentration in the soil can go is one the team is keen to explore, and the electrokinetics trial this summer is just one of several methods being trialled.

"Fuel is very complex; it has thousands of different compounds within it, each with different degrees of toxicity, and you need a diverse range of microorganisms and conditions to degrade those compounds at varying stages," Mr Spedding said.

"We can't clean everything entirely, but we want to clean it to a point where there is a very low risk to the environment or human health.

1. The remediation team at Casey last summer. (Photo: Stuart Shaw)

Clean-up manual has international impact

The work of Australian Antarctic Division remediation scientists guided the development of an Antarctic Clean-Up Manual, which was adopted by the Antarctic Treaty Consultative Meeting (ATCM) in 2013.

Chair of the ATCM's Committee for Environmental Protection, Ewan McIvor, said Australia's experience and expertise in cold climate remediation is well recognised by the Antarctic Treaty Parties.

"The national Antarctic programs are increasing their use of renewable energy sources, but the reality of Antarctic operations is that a lot of fuel is still used, and inevitably there are occasional spills or leaks into the environment," Mr McIvor said.

"Countries are obliged to clean up their contaminated sites, and so the purpose of the manual is to present practical guidance on how best to do that, including approaches to site evaluation and containment, as well as techniques and technologies suitable for remediation in Antarctica."

Other Antarctic Treaty parties such as Argentina, the United States and Brazil are also tackling similar issues, and the exchange of knowledge and personnel helps to enhance the success of individual and collective clean-up efforts.

"In 2014 we had a Brazilian scientist embedded with the team at Casey and this year two of our team have travelled to Brazil to share our learnings, as they formulate a plan to clean up the site where their station burned down in Antarctica five years ago," remediation Project Manager, Mr Tim Spedding, said.

"We're keen to share our experiences from decades of trial, error and triumphs, to help other Antarctic nations minimise the human impact on the extraordinary and fragile Antarctic environment."

"To remove all contaminants you would effectively have to remove the soil in its entirety from Antarctica. But with less than one per cent of the continent ice-free, those areas are home to 99 per cent of Antarctic terrestrial biodiversity, so it's important to keep the soil in place."

The team is now drawing on decades of experience in cold climate remediation and eco-toxicology research (*Australian Antarctic Magazine* 27: 3, 2014) to develop soil re-use guidelines for the Australian Antarctic Program.

"Currently there are no hard and fast target numbers for fuel contamination, as there are many different scenarios where you could reuse soil," Mr Spedding said.

"You need to consider where it's going to be re-used, in what manner, what potential impact that might have and what conditions you are trying to meet.

"For example, if the remediated soil is for unrestricted re-use on station, there needs to be much lower concentrations of residual fuel. But in certain situations, such as using it as back-fill for building foundations, the residual contaminant concentration can be higher, while still being a very low risk to the environment or human health."

So far, around one quarter of the soil remediated at Casey station has been reused in building foundations.

NISHA HARRIS

Australian Antarctic Division

*Australian Antarctic Science Project 4036.

2. *The Casey station remediation site with the biopiles in the foreground under textile liners to control dust in the often dry and windy conditions. (Photo: AAD Risk and Remediation Team)*

3. *Jeremy Richardson undertaking some pre-deployment testing of the electrokinetic equipment at the Australian Antarctic Division in Kingston. (Photo: Robbie Kilpatrick)*

Antarctic place names go to the dogs

Huskies used during the 'Heroic Age' of Australia's Antarctic exploration have been immortalised, with their names bestowed on a variety of prominent landmarks across the icy continent.

The Australian Antarctic Division Place Names Committee has named 26 islands, rocks and reefs after the beloved dogs, which played a critical role in Douglas Mawson's Australasian Antarctic Expedition (AAE) from 1911 to 1914.

Committee Chair, Ms Gillian Slocum, said the most prominent features were named after the most important dogs.

"Lassesen Island, in the Mackellar Islands, is named after Norwegian explorer Roald Amundsen's favourite husky," Ms Slocum said.

"The dog was part of Amundsen's party when he became the first person to reach the South Pole in 1911. Unfortunately Lassesen died on the return journey, but Amundsen gave Mawson another dog with the same name."

1. The names of huskies from Douglas Mawson's Australasian Antarctic Expedition (1911–1914) have been bestowed upon 26 islands, rocks and reefs off Cape Denison, where the expedition was based. (Frank Hurley)

The smaller Pavlova Island recalls the husky Pavlova, named after famed Russian dancer Anna Pavlova, who was a friend of AAE member Belgrave Ninnis and greatly interested in the AAE. Ninnis cared for the huskies during the AAE, but died during Mawson's ill-fated Far Eastern Party sledging journey, when he and six of the party's best dogs, as well as most of the supplies, fell through a crevasse.

Other huskies named after royalty, explorers, sporting champions, singers, comedians and Greek mythology, lend their names to features such as Mary Island, Caruso Rock, Jeffries Rock and Franklin Reef.

Five features within areas of scientific importance in the Australian Antarctic Territory have also received new names. Cavities Lake and Malleefowl Hill, both in the Rauer Group, reflect the physical attributes of each feature.

"Cavities Lake is named for a series of indentations or holes in the lake floor visible through the clear, shallow water, while Malleefowl Hill is a pyramid-shaped hill reminiscent of this native Australian bird's nest," Ms Slocum said.

The Committee also named a glacial valley near Davis research station "Adams Flat", after the late Dr Neil Adams, a meteorologist and Australian Antarctic Medal recipient. The name honours Dr Adams's contribution to the development of the science of Antarctic meteorology and his work as a forecaster for the Australian Antarctic Program.

In an effort to avoid dual naming, the Place Names Committee also adopted names for 46 features previously named by the United States and New Zealand.

Place Names Committee member and cartographer, Ms Ursula Harris, said the latitude and longitude of every feature is confirmed when they are named. The approved name, the feature's coordinates, and a narrative describing the feature, are recorded in the Australian Antarctic Gazetteer and Scientific Committee on Antarctic Research (SCAR) Composite Gazetteer of Antarctica.

"Accurate names and positions are critical for safety and science," Ms Harris said.

"We are constantly improving our gazetteer so scientists and deep field traverse parties will be able to accurately communicate the location of their activities."

High resolution satellite imagery has also enhanced the ability to identify features, such as distinguishing between an island and an iceberg or a close-knit group of small islands.

Ms Harris said the naming of Antarctic features is still as important today as it was when former Australian Antarctic Division Director Dr Phil Law encouraged Sir Douglas Mawson to join the first place names committee in May 1952.

The Australian Antarctic Division Place Names Committee consists of representatives from all work areas of the Australian Antarctic Division and an external member from the Department of the Environment and Energy.

Australian Antarctic place names can be searched for in the Australian Antarctic Gazetteer http://data.aad.gov.au/aadc/gaz/.

WENDY PYPER

Australian Antarctic Division

Antarctic films offer visual surprise

The 1954 science fiction film, *Target Earth*, about killer robots from Venus, was considered by Australian Antarctic expeditioners to be so bad that it was only watchable after a few stiff drinks. Despite the bad rap, a double screening with the similarly dire *Conquest of Space*, was always well attended, according to Australian Antarctic Division Senior Communications Technical Officer Ian McLean.

Mr McLean volunteered his services as a projectionist in the days when Australia's Antarctic stations provided 16 mm feature and short films for the entertainment of expeditioners.

With the advent of DVDs, many of these films, including *Target Earth*, have now been donated to Australia's National Film and Sound Archive (NFSA), as an internationally significant example of "cinema in isolation".

NFSA Curator of Film, Sally Jackson, said the collection of more than 600 films was a "living archive" of Antarctic film culture.

"The expeditioners interacted with their films, rating them out of five, leaving notes for each other about the quality of the plots and acting, and even editing some of the films by splicing in little 'visual surprises' from other films," Ms Jackson said.

"For wintering expeditioners, many of whom returned year after year, this editing was a way to keep the films alive – to make them exciting again for the same audience.

"Unlike cinema today, where people just watch a film and then leave, I can imagine the expeditioners would have talked over the top of the films and poked fun at them, while they were screening."

According to Mr McLean, who has wintered nine times between 1992 and 2011, this is exactly what happened.

The 1940 version of *Pride and Prejudice*, starring Greer Garson and Laurence Olivier, for example, was so regularly viewed that expeditioners took to turning off the sound and voicing their own dialogue in British Regency English.

The 1940 classic Australian film, *Forty Thousand Horsemen*, about the Australian Light Horse in Palestine, was creatively edited during the Battle of Beersheba cavalry charge.

"There was a scene with hundreds of soldiers on horseback charging across the sand dunes and someone spliced in a scene from a 1970s film of people riding motorcycles in the opposite direction," Mr McLean said.

And then there was the 1956 melodrama *Tea and Sympathy*, about a young man's battle with his sexuality. Ms Jackson said that inside the film's case she found a note reading "Stop! This film is terrible. Don't watch it."

"*Tea and Sympathy* is one of David Stratton's [renowned English-Australian film critic] favourite films. When we told him what the Antarctic expeditioners thought, he frowned," Ms Jackson said.

Many of the feature and short films in the Antarctic collection are from the 1940s, 50s and 60s. When Mr McLean arrived in 1992 he sought to update the collections and managed to acquire a range of 1990s films from Village Roadshow.

"We got the films for free; the only caveat was that we weren't allowed to charge admission or sell them," he said.

As a projectionist, Mr McLean said he often spent more time managing the projector than watching the film.

"I spent a lot of time making sure the projector didn't blow up, or that the film didn't unspool all over the floor, or catch on fire," he said.

"We sent the projectors off for maintenance and repair every year, but they seemed to return in a similar condition."

Films were shown every Wednesday and Sunday night and were generally chosen by the 'slushy' (kitchen-hand).

To choose the films for the NFSA collection, Ms Jackson said curators selected the expeditioners' favourites and those considered too awful to watch. They also chose films with an Australian connection, with cases that had comments written on or inside them, and oddities – such as *Jaws 3D*.

Target Earth and a number of short films were screened in Canberra at midwinter, to the delight of past expeditioners and the general public, and future Antarctic film nights are planned.

"Many of these films are generally available, but the fact that these particular ones have been to Antarctica and have been rated, lends another dimension to the whole story," Ms Jackson said.

"The only place I can think of that would have the same caché as Antarctica, is space. What do astronauts watch on the International Space Station?"

Perhaps *Target Earth* would be better received in space.

WENDY PYPER

Australian Antarctic Division

1. *Australian Antarctic Division Senior Communications Technical Officer Ian McLean (far right) in conversation with NFSA Curator of Film, Sally Jackson (far left), and expeditioners from Casey research station (on the screen) during the midwinter film festival in Canberra. Some of the Antarctic film cases are stacked in the foreground. (Photo: NFSA)*
2. *Some of the Antarctic films donated to the National Film and Sound Archive, including the poorly rated science fiction film,* Target Earth. *(Photo: Sally Jackson)*

Van life

In the early days of the Australian National Antarctic Research Expeditions (ANARE), caravans were used as temporary accommodation during the construction of station buildings, and for reconnaissance and survey journeys. Tracked vehicles, such as Weasels and Caterpillar tractors, were used to tow caravans into the field.

Today, vans are still used as accommodation for short periods in the field, allowing scientific projects and field operations to reach remote parts of the Australian Antarctic Territory. Vans are towed using oversnow transport vehicles such as Hägglunds, and are often accompanied in a traverse convoy by Caterpillar tractors, towing 20 tonne sleds with equipment and supplies. Vans have traditionally been painted international orange for maximum visibility.

The history of vans used by Australia in Antarctica provides a fascinating insight into the evolution of design. In practice, it was often a case of trial-and-error as to which design would work best in the extreme Antarctic conditions. In terms of performance and comfort, each had its strengths and weaknesses.

Barge survival caravans

Built in 1953 by Benson and Shaw in Melbourne, expeditioner Bob Dovers' design of the barge caravans may have been influenced by the French 'scow' – a flat-bottomed boat used for transporting cargo to and from ships in harbour. They were constructed with marine plywood in two pieces, bolted together with narrow steel-capped sledge runners for towing across the ice.

Watertight and weatherproof, barge vans were designed to float if they broke through the ice. During an epic journey to Scullin Monolith in May 1954, this capability was inadvertently put to the test. In his diary, Officer-In-Charge Bob Dovers wrote: "A very worrying night ensued. The caravan was under constant bombardment by ice fragments that rattled on the plywood walls…We could hear water lapping…and the caravan was continually bumped by moving floes that scraped loudly against the thin plywood hull".

Despite their simple design, barge vans were heavy when loaded with field equipment, and difficult to haul.

PID caravans

Built in 1957 at the Gordon Institute of Technology in Geelong, with design input from expeditioner John Bechervaise, the PID caravans were one of the first purpose-built for traverses. Named 'PID' after the colloquial expression for a bed, they were light but strongly built, and mounted on cargo sledges. Constructed with bondwood, their sloped walls were designed to glide through sastrugi ridges, and reduce wind effect and drift accumulation on the lee side.

Aneata caravan

Designed and built by expeditioner Don Butling in 1960, using spare Oregon framing timbers and plywood, the Aneata caravan was bolted onto a surplus Weasel cargo sledge with steel-shod runners (*Australian Antarctic Magazine* 25: 22-23, 2013). Due to the lack of available insulation material, only a 50 mm air gap separated its occupants from the harsh Antarctic weather.

1. A D4 tractor towing a meteorology van ['freighter van'] in the Framnes Mountains. (Photo: Max Corry)

2. *A PID caravan on traverse to the Prince Charles Mountains in 1960. (Photo: Geoffrey Newton)*

3. *A Hägglunds towing a Franklin caravan at Davis in 1985. (Photo: Paul Butler)*

Named for Don's wife, the Aneata caravan made several trips across the plateau to a site called 'S2', 80 km inland from Wilkes. It housed expeditioners during the 1962 epic journey from Wilkes to the Russian base, Vostok; a distance of 1500 km traversing to an altitude of 2500 m. Temperatures plummeted to –80°C, earning Aneata the moniker 'Ice Maiden of Antarctica'. Later used as an emergency hut at the Haupt Nunataks, it was eventually returned to Australia, and today occupies a unique place in the Antarctic Division's heritage collection and Australian Antarctic history.

RMIT vans

In the 1960s, the Royal Melbourne Institute of Technology (RMIT) constructed a traverse van based on the PID design, but built using fibreglass and composite mouldings in a two piece shell. With smooth lines and rounded corners, its lightweight design was mounted on a Norwegian-type sledge.

The external fibreglass skin was insulated with polyurethane. An internal skin of fibreglass and an external coat of resin finished the sandwich style construction. A Perspex observation dome mounted in the roof, provided natural light. Inside were benches and four bunks that were integrally formed into the walls, and a custom kerosene heater.

After a series of modifications over the years, this enduring and versatile form of field accommodation is still in service today.

ANARE living caravans

Used extensively in the early 1960s, the ANARE living caravans, known as 'freighter vans', were designed as a four berth, sledge-mounted container, constructed with light-gauge pressed steel sections that could be hauled by a D4 tractor. The van featured double armour plate glass windows and a rooftop escape hatch. It was insulated with three inch Onazote rubber, while the walls and ceiling were clad with Masonite. Gas bottles in the cold porch supplied fuel for the stove and radiator. Ventilators were provided in the roof and at either end of the van, and electrical lighting was powered by a generator mounted on the tractor.

Franklin caravans

For many Australians, the iconic Franklin caravans were synonymous with family vacations. From the mid-1970s until the mid-1980s, ANARE arranged for several fibreglass moulded Franklin caravans to be manufactured to serve as traverse vans, automatic weather stations and auroral radar observation shelters. The Franklin caravans were insulated with two inch thick walls. The traditional chassis was replaced with Smith sledges. Still sought after today by vintage enthusiasts, Franklin holiday caravans were renowned for their longevity.

Container traverse vans

Today, container traverse vans constructed from insulated panels or shipping containers, mounted on traverse sleds, are used in the field. Capable of enduring long periods of overland travel behind tracked vehicles in tough conditions, they often serve as living vans, science laboratories, communications centres, or generator vans, in modular field camps. Container traverse vans are well-insulated and provide a high quality working and living environment.

Opportunity or ordeal

Traversing in Antarctica is a noisy, bumpy and slow process – caravans offer the joy of modest comfort and cosiness in an otherwise hostile climate. In the words of Jim Dragisic, team leader of the 2002–03 Prince Charles Mountains Expedition of Germany and Australia traverse: "For some, traversing can be an ordeal that they would sooner forget; for others it can be a special experience that presents many challenges and gives them the opportunity to see some of the most wonderful sights imaginable".

TESS EGAN[1] and DAVE McCORMACK[2]

[1]Librarian, Australian Antarctic Division

[2]Former expeditioner and Phillip Law Medal recipient

The longest living Australian Antarctic motorcycle

In 2013 George Cresswell set out to collect information on motorcycles that had been taken to Antarctica by members of the Australian National Antarctic Research Expeditions (ANARE).

George had taken a 350 cc Velocette to Mawson in 1960 and expected that other motorcycle enthusiasts had since done the same. What he didn't expect was the number – some 35 bikes between 1960 and 1980. One was a 500 cc single cylinder Matchless, which stood out because of its long life, from 1968 to 1977.

1. *The Matchless G80 500 cc single at Mawson in 1968, with its upswept exhaust and muffler and South Australian number plate. Bruce McDonald is believed to be the rider. (Photo: Expeditioner photo)*

2. *The Matchless motorcycle towing skier Neville Dippell on the sea ice at Mawson's Horseshoe Harbour. (Photo: David Parer)*

Malcolm Robertson had a love affair with the Matchless during his year as geophysicist at Mawson in 1970. When the 1970 expeditioners arrived at the station they found that it was littered with all sorts of interesting relics, including, as Malcolm wrote, "a 500 cc single cylinder Matchless motorcycle of indeterminate age that still ran. I claimed this immediately as a geophysics field vehicle and registered it MC01".

The Matchless provided much entertainment and was used around the station as a bit of a trail bike, bouncing its way to the remote corners of the boulder-strewn site and occasionally onto the lower reaches of the ice plateau.

One of its uses was to tow intrepid skiers, and a photo shows it speeding towards an equally intrepid photographer, David Parer, who, thankfully, avoided being decapitated by the tow rope. Close inspection shows a rope wrapped around the front wheel in an attempt to improve traction.

Some time into 1970 Malcolm painted the petrol tank yellow and fitted a horizontal exhaust muffler from the Triumph Thunderbird that "Snow" Williams had taken down in 1962. The yellow petrol tank, horizontal exhaust and the sidecar made the Matchless distinctive.

Malcolm had taken a Super8 movie camera to Mawson and in 2016 it was transcribed to digital. The camera had been passed from person to person during the year and there is good footage of station life, including when Malcolm taught himself to do a pirouette on the Matchless on the sea ice.

In 2010 for the 40th anniversary of wintering at Mawson, Malcolm wrote an exciting yarn, *The Day the Ice Turned Black*, for the ANARE Club journal, *Aurora*, about an adventure that he had with David Parer.

In early November 1970 Dave suggested that they take the Matchless twelve miles out to Rookery Island so that he could photograph the giant petrels on their nests.

> Although we had been having twenty-four hours daylight for some time and summer was just around the corner, we didn't give the state of the ice a second thought. Even as we motored past

patches of seaweed floating in black holes in the ice, we didn't think that the roadway we had been safely riding along for the past months might be wearing a little thin, as the warmer ocean currents swirled around underneath.

How wrong we were! Before long, as we approached the rookeries, the ice became noticeably darker. From experience we knew that at thicknesses quite safe for man, beast or machine, it was either a pale blue or white, yet stretching out in front of us was an expanse of quite black ice... we could feel the ice moving and creaking as we covered the final metres.

Dave shot off several rolls of expensive film and Malcolm looked down from the island and could see that they had crossed quite a dark patch of ice. He decided that they should go around it on the way back. But Dave "headed straight back the way we had come, while I started out on the circuitous route..."

Suddenly there was a cry from Dave and I turned to see him disappear into the icy waters through the ice. He quickly hauled himself out only to find that the ice would break under his weight. I raced over and lay on my stomach, reaching out a hand, but I couldn't see how that would help. Dave hauled himself up again, but again the ice broke and he fell back in. We both saw the problem: "Swing the cameras around to your back," I screamed. "They're breaking the ice when you haul yourself up and lie on them!"

He hauled himself out again and this time the ice held. He slithered towards me and I pulled him to firmer ice and helped him to his feet. We staggered back to dry land to review the situation. One expeditioner soaking wet, two cameras and lenses soaked in sea water, twelve miles from base, temperature below freezing...

We rationalised our clothing - Dave took my windproofs and turned himself into a walking wet-suit, I steeled myself for a chilly return trip with only jumper and strides to keep the wind out.

[We] kept well away from any darker sections of ice, and especially away from floating seaweed and drove slowly to reduce the wind chill, but it didn't seem to help much. On arrival, both freezing cold, we sheepishly slunk into our dongas to change and warm up.

"I don't think we ever told anyone about that little adventure, but I can assure you we both had nightmares for several weeks afterwards," Malcolm said.

No yarns or photographs have come in about the Matchless from 1971 to 1973, but Narra Johnson said that in 1974 the winterers were "spoilt as far as transport was concerned - we had a fleet of the jazzy and nifty skidoos".

More than half a year later, with summer approaching, Narra went on a trip towards Welch Island with Feathers Walters in the armchair of the Matchless's sidecar (an easy chair taken from the recreation room) and Marko Oliver on the pillion seat. It was 11 pm and the sun was behind them. Visibility was good, but black ice encouraged Narra to be prudent and turn for home.

They got up to a good speed as they rode into the low setting sun reflecting off the ice. All was good until they hit a pile of snow and the bike stopped dead. "Marko went hurtling over my shoulders accompanied by Feathers from his armchair and landed on the softish snowdrift." Narra landed upside down on the front wheel still hanging on to the handlebars. But it all ended well. The stalled engine started and they returned to the station.

The last gasp of the Matchless seems to be at the 1977 midwinter race around Horseshoe Harbour. According to the station report (Aurora, Spring 1977, p 200) "the red hot favourites with the bookies were Des Williams and Col King on the motorbike. The race began 10 minutes late, with a fast track and threatening drift conditions. The red hot favourites suffered major mechanical breakdowns with the collapse of their back wheel and withdrew"... RIP Matchless.

GEORGE CRESSWELL

(Mawson 1960)

3. Malcolm Robertson astride the Matchless and sidecar that he claimed during the 1969-70 changeover. (Photo: David Parer)

4. Malcolm Robertson on the Matchless with its MC01 number plate near Mawson in 1970. (Photo: Allan Foster)

How science informs and shapes Antarctic policy

Antarctic scientists work on a range of research topics, but for scientists at the Australian Antarctic Division, issues that inform national and international policy are usually the highest priority.

In this context, policy can mean guidelines or rules about the way Antarctica is managed or international decision-making on global issues such as climate change. At the top of the Antarctic policy tree is the Antarctic Treaty and the related international agreements that constitute the Antarctic Treaty system. The Antarctic Treaty was signed in 1959 to ensure "in the interest of all mankind that Antarctica shall continue for ever to be used exclusively for peaceful purposes and shall not become the scene or object of international discord".

The Protocol on Environmental Protection to the Antarctic Treaty, which designates Antarctica as a "natural reserve, devoted to peace and science", was signed in 1991 and came into force in 1998. The Protocol provides unparalleled environmental protection for the entire Antarctic continent, and clear guidance on the important values that are to be conserved and protected.

The Protocol established the Committee on Environmental Protection (CEP) to support all countries to protect the Antarctic environment. The CEP is an important avenue for scientists to inform international discussions and decisions about the way the environment is managed. In recent years, Australian scientists, working with their counterparts in policy, have used their research to facilitate significant policy changes. Examples of this science include a better understanding of:

- the pathways and type of alien species introductions;
- the distribution of biodiversity in terrestrial Antarctica; and
- how to remediate contaminated soils in Antarctica.

The flow-on effects of this research are broad-reaching and include improvements in biosecurity practices (*Australian Antarctic Magazine* 14: 28, 2008), a better foundation for protecting distinct biogeographic regions (*Australian Antarctic Magazine* 23, 19, 2012), and the ability to clean up the environmental impacts of human activities (see page 22).

Scientists also support Australia's engagement in other international bodies that require high-quality science to shape policy, such as the Convention for the Conservation of Antarctic Marine Living Resources (CCAMLR) and the Agreement on the Conservation of Albatrosses and Petrels. Science has informed decision-making and policy changes in both cases. Examples include better ways of assessing fisheries sustainability, improved understanding of the impacts of fishing on the broader ecosystem, and improvements in fishing techniques to reduce the bycatch of seabirds (*Australian Antarctic Magazine* 27: 14-15, 2014). Australian Antarctic scientists also contribute directly and indirectly to climate change policy, through research papers and input into the Intergovernmental Panel on Climate Change reports.

Science can also facilitate change at more local levels, helping to ensure an environmentally responsible approach to the management of Australian activities in Antarctica. Australian Antarctic Division scientists are often involved in supporting policy development on issues such as the human footprint in Antarctica, minimising wildlife disturbance, and monitoring and evaluating changes in the Antarctic environment.

So what helps a successful transition from science to policy? Clear and regular communication between scientists and policy-makers is fundamental. If scientists understand what the policy priorities are (both at international and national levels), they will be better placed to target their research accordingly. Presenting research results in a way that is accessible to policy-makers is also important. The results of multinational research collaborations can often be influential in international policy forums like the CEP and CCAMLR, and expanded collaborations have the added benefit of helping to disseminate the research more broadly. International and rigorous peer-review of research, for example, like that associated with publication in scientific journals, also helps to reassure policy-makers that the research is a robust and unbiased resource to inform their decisions and/or change policy.

In all the examples outlined here, science has been used to improve policy and achieve better environmental outcomes for Antarctica and the Southern Ocean.

ALEKS TERAUDS

Section Head - Biodiversity Conservation, Australian Antarctic Division

Chief Officer – SCAR Standing Committee on the Antarctic Treaty System

1. Antarctic science has informed policy decisions that help protect Macquarie Island's black-browed albatross (pictured) and other albatross and petrel species, through the Agreement on the Conservation of Albatrosses and Petrels. (Photo: Kim Kliska)

Unlocking the icy secrets of Australian climate variability

A deep-field mission to recover an Antarctic ice core up to 2000 years old, aims to shed further light on the long-term influences on Australian weather and climate.

Six researchers will spend up to 50 days south of Mt Brown, 330 km east of Davis research station, drilling a core to a depth of around 350 m this summer.

The Australian Antarctic Program project* is led by Dr Tessa Vance from the Antarctic Climate and Ecosystems Cooperative Research Centre.

Dr Vance said there is little information on how weather patterns, formed in the Indian Ocean, have changed over time periods longer than a few decades, and how this affects Australia.

"The region is known as a 'cyclone nursery' as it's where many storms are 'born' before they head from west to east across the Southern Ocean and impact both Australia and East Antarctica," she said.

"A new ice core record from Mount Brown south will provide us with a snapshot of the climate history of the Indian Ocean and hopefully some insight into climate variability in Australia over the last one to two millennia."

The chemical constituents in Antarctic ice cores, including traces of hydrogen and oxygen, sulphur from volcanoes, and sea salts, along with the amount of snowfall per year, provide information on past climate and climate processes.

"The information in ice cores helps us understand how the climate changes, and to view predicted future change through the lens of past variability," Dr Vance said.

In 2015, scientists developed a 1000 year record of drought in eastern Australia from the existing Law Dome ice core record (*Australian Antarctic Magazine* 30: 18, 2016).

"The Law Dome record showed us that prolonged droughts in eastern Australia are part of the natural climate cycle," Dr Vance said.

"We hope an ice core from Mt Brown will provide us with another snapshot of climate variability in the Indian and south-west Pacific oceans, and more insight into long-term climate variability in Australia."

**Australian Antarctic Science Project 4414.*

Dr Tessa Vance hopes an ice core collected from Mount Brown this summer will provide further insights into Australian weather and climate. (Photo: Jill Brown)

Rare sub-Antarctic orchid flowers far from home

The critically endangered grooved helmet orchid (*Corybas sulcatus)* has flowered for the first time away from its native home of Macquarie Island.

The orchid was collected by botanist Natalie Tapson from the sub-Antarctic island earlier this year, and transplanted in its new home at the Royal Tasmanian Botanical Gardens (RTBG) in March.

Listed as being critically endangered, the small orchid reaches just 1–2 cm in height. It is only found on Macquarie Island, making it one of the rarest species on Earth.

The grooved helmet orchid from Macquarie Island. (Photo: RTBG)

"The population is very small, so it's important to secure the species with seed collections in case of threatening events such as drought," Australian Antarctic Division biologist Dr Dana Bergstrom said.

The orchid will be used by the RTBG's Native Orchid Conservation and Research Program to understand the conditions in which it can survive and flourish.

Dr Tapson, who spent three months on Macquarie Island collecting seeds for the RTBG's Tasmanian Seed Conservation Centre, also collected 12 other plant species, including the critically endangered Macquarie Island cushion plant *(Azorella macquariensis).*

The collection will help secure the plant diversity of the entire island's flora.

New Antarctic bus

A new bus with balloon tyres weighing half a tonne each, will provide an enhanced level of comfort and service as it transports expeditioners between Wilkins Aerodrome and Casey research station this summer.

The $1.2 million, 22 tonne vehicle will carry 36 expeditioners; 17 more than the current steel-tracked bus, which has been in service since 2008.

Australian Antarctic Division Mechanical Supervisor, Cameron Frost, said the new bus has been specially designed for Antarctic conditions.

The new Antarctic bus, built in Calgary, will transport 36 expeditioners between Wilkins Aerodrome and Casey research station. (Photo: Dominic Hall)

"The bus was manufactured in Calgary and is a smaller version of the buses used for glacier tours in Canada and by the United States Antarctic Program at McMurdo Station," he said.

"It has six all-terrain balloon tyres, measuring 1.5 metres high, which are designed to help it drive smoothly over soft, snowy surfaces; while electric and diesel heaters will keep the engine and passengers warm in sub-zero temperatures."

The engine is the same as those in cranes used at Casey station, enabling the diesel mechanics to service the vehicle and interchange parts when required.

The new bus will accommodate most of the 38 passengers delivered to Wilkins Aerodrome on each flight of the A319 intercontinental aircraft.

Engineer, Michael Packer, in the Advanced Wastewater Treatment Plant, built inside two shipping containers. (Photo: Eliza Grey)

Taking the waste out of wastewater

An advanced wastewater treatment plant will be installed at Davis research station next winter to process human and kitchen waste into drinking quality water.

Australian Antarctic Division Engineer, Michael Packer, said the $1.5 million dollar plant is self-contained, low maintenance and designed to operate remotely (see *Australian Antarctic Magazine* 30: 2-3, 2016)

The wastewater will undergo a series of physical and chemical processes to produce water that exceeds the Australian and World Health Organisation drinking water guidelines. Once installed, it will be the best treatment system in Antarctica.

The advanced plant, built inside two shipping containers, has been trialled in Hobart over the past two years. While there are no current plans to use the purified water for drinking, it will ensure the water discharged into the marine environment has a negligible impact.

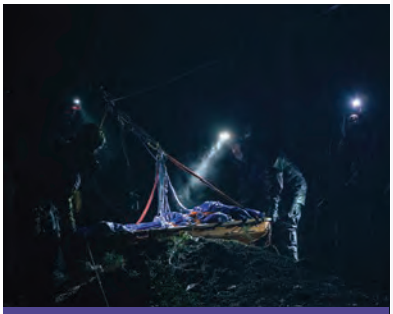
Specialised tradespeople will install the advanced plant over winter, with commissioning scheduled for late 2018. Advanced plants will be built at Australia's other Antarctic stations in the future.

The plant was built by the Antarctic Division's engineers and tradespeople, with funding, research, design and testing input from academia and industry partners, including the Australian Water Recycling Centre of Excellence, Victoria University, the University of Melbourne, Veolia Waste, TasWater and AECOM.

Antarctic doctors left out in the cold

Antarctic-bound doctors spent a wet and wild week in the Tasmanian wilderness in July, honing their cold climate and remote medicine skills.

During the eight day Expedition Medicine Winter Course, run by the University of Tasmania and Australian Antarctic Division, participants were challenged to abseil down cliffs and undertake search and rescue scenarios in dark, wet and freezing conditions. Participants also practiced cold injury management, remote area communication and navigation skills, and considered pre-expedition planning and stocking an expedition medical kit.



Medical professionals and wilderness instructors practice their stretcher-bearing skills in challenging conditions, during an Expedition Medicine course in Tasmania. (Photo: Heath Holden)

Each of Australia's three Antarctic stations, and sub-Antarctic station on Macquarie Island, has a medical practitioner who is responsible for the care and well-being of all expeditioners, with the support of the Antarctic Division's 24/7 telemedicine systems, connecting them to experts based in Hobart.

The expedition medicine course is open to the public and is offered as part of the University of Tasmania's Master of Public Health (Remote and Polar Health) course.

Antarctic time lapse

Leading Australian photographer Martin Walch has been awarded the 2017 Australian Antarctic Arts Fellowship.

Dr Walch specialises in time-lapse and still photography and will travel to Mawson research station to spend three months capturing the unique icy environment on camera.

Photographer Martin Walch will travel to Mawson as this year's Australian Antarctic Arts Fellow. (Photo: Gerrard Dixon)

"My work will offer new ways of understanding the movements of water, ice, animals and people, as they go about their daily lives under the ever-present summer sun," Mr Walch said.

Dr Walch is a part-time lecturer at the University of Tasmania. He has a Bachelor of Fine Art with Honours in photography, a Master of Fine Arts by Research in digital stereoscopic photography and landscape, and a PhD in fine art.

Dr Walch's Antarctic work will be exhibited in Tasmania and nationally, while an archive will be collected by the world renowned Center for Art + Environment, at the Nevada Museum of Art.

Dr Walch's Antarctic Fellowship will use techniques and strategies developed during his five-year Australian Research Council collaboration with Dr David Stephenson, entitled *The Derwent Project*, which is currently on display at the Tasmanian Museum and Art Gallery.

The Antarctic Arts Fellowship provides opportunities for people from the creative community to experience Antarctica first hand, and share this with the broader Australian community through their chosen art form.

KIM KLISKA

Freeze Frame

Field biologist Kim Kliska spent three seasons working with albatrosses and petrels on Macquarie Island, between October 2015 and April 2017. Prior to this she spent five years working in biological research around Australia. She has also worked in outdoor education, in Australia and overseas, leading young people on international expeditions to the Himalayas and South-East Asia.

This photo of a black-browed albatross chick was taken while I was working as a field biologist on the Macquarie Island albatross and petrel program – a long-term study to help manage and conserve threatened seabirds. I was conducting nest checks on the steep slopes of the island when I spotted this curious youngster 100 m away. In between showers, this photo was taken with an Olympus OMD E-M1, set at F6.3 and 1/400 s. I am passionate about capturing photos of the wildlife I am privileged to work with, so that I can share the experience with others and inspire them to care for these amazing creatures.

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